DOCUMENT RESUME

ED 089 736 IR 000 448

AUTHOR	Sullivan, Dennis J.; Smith, Edgar A.
TITLE	Instructional Media and Carrel Systems. Final Report.
INSTITUTION	Air Force Human Resources Lab., Lowry AFB, Colo. Technical Training Div.; Hughes Aircraft Co., Los Angeles, Calif.
REPORT NO	AFHRL-TR-72-48
PUB DATE	Feb 74
NOTE	213p.
EDRS PRICE	MF-$0.75 HC-$10.20 PLUS POSTAGE
DESCRIPTORS	*Audiovisual Aids; Audiovisual Centers; Audiovisual Instruction; *Carrels; Computer Assisted Instruction; Glossaries; Individualized Instruction; Institutional Facilities; *Instructional Media; *Instructional Systems; Instructional Technology; Media Selection; Military Training; Multimedia Instruction; Performance Criteria; Study Centers; Training Techniques
IDENTIFIERS	Advanced Instructional System; AIDS; Air Force; AIS; Audio-Visual Instructional Display System

ABSTRACT

Implementation of a major computer-managed individualized instructional system requires considerable attention to both instructional environments and the media hardware and software employed. This report examines the instructional milieu with respect to performance analyses, learning carrel requirements and the equipment and techniques required to develop and maintain the software for a large scale individualized instructional program. (Author)

AFHRL-TR-72-48

IR FORCE
HUMAN RESOURCES
LABORATORY

ED 089736

INSTRUCTIONAL MEDIA AND CARREL SYSTEMS

By

Dennis J. Sullivan
Hughes Aircraft Company
Culver City, California 90230

Edgar A. Smith

TECHNICAL TRAINING DIVISION
Lowry Air Force Base, Colorado 80230

February 1974

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Approved for public release; distribution unlimited.

IR 000446

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This final report was submitted by Hughes Aircraft Company, Culver City, California 90230, under contract F33615-71-C-1860, project 1193, with the Air Force Human Resources Laboratory (AFSC), Technical Training Division, Lowry Air Force Base, Colorado 80230. Dr. Edgar A. Smith, Technical Training Division, Air Force Human Resources Laboratory, was the contract monitor.

This report has been reviewed and cleared for open publication and/or public release by the appropriate Office of Information (OI) in accordance with AFR 190-17 and DoDD 5230.9. There is no objection to unlimited distribution of this report to the public at large, or by DDC to the National Technical Information Service (NTIS).

This report has been reviewed and is approved.

MARTY R. ROCKWAY, Technical Director
Technical Training Division

Approved for publication

HAROLD E. FISCHER, Colonel, USAF
Commander

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER
AFHRL-TR-72-48

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Instructional Media and Carrel Systems

5. TYPE OF REPORT & PERIOD COVERED
Final

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Dennis J. Sullivan
Edgar A. Smith

8. CONTRACT OR GRANT NUMBER(s)
F33615-71-C-1860

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Hughes Aircraft Company
Centinela and Teale Streets
Culver City, California 90230

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
1193-OB-06

11. CONTROLLING OFFICE NAME AND ADDRESS
Hq Air Force Human Resources Laboratory
Brooks Air Force Base, Texas 78235

12. REPORT DATE
February 1974

13. NUMBER OF PAGES
210

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)
Technical Training Division
Air Force Human Resources Laboratory
Lowry Air Force Base, Colorado 80230

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Learning centers, audio visual, multi-media, technical training, training media, training resources, training research.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Implementation of a major computer-managed individualized instructional system (Advanced Instructional System) requires considerable attention to both instructional environments and the media hardware and software employed. This report examines the instructional milieu with respect to performance analyses, learning carrel requirements and the equipment and techniques required to develop and maintain the software (audio-visual materials) for a large scale individualized instructional program.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SUMMARY

Problem

The objective was to conceptualize and design two related instructional systems. The first is a carrel system capable of information presentation, evaluation, remedial instruction, and reference document storage and retrieval. The second in the development of hardware support and production techniques required to generate the instructional material utilized in such a carrel system.

Approach

This effort consisted of a training and environment analysis of an AIS identified course, preparation of a functional description of proposed configurations and development of several physical carrel prototypes. A media development system in support of the instructional environment was designed. Discussion centers on all required items for the production, processing, reproduction, and packaging of software systems in all selected media.

Results

Results of this study are a technical manual and several physical carrel prototypes. The AIDS (Audio-Visual Instructional Display System) was designed and fabricated by the contractor. Remaining carrels were fabricated by Lowry Air Force Base Training Services Division. All prototype carrels are currently in use at Lowry Air Force Base, Colorado.

PREFACE

This study was initiated by the Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado 80230, under Project 1193; Task OB. The Project Scientist was Mr. Joseph Y. Yasutake and the Task Scientist was Dr. Edgar A. Smith. The Training Department, Training Systems Engineering operation, Hughes Aircraft Company, Los Angeles, California 90230, accomplished this study under contract F33615-71-C-1860. Mr. G. A. Haaland was the Project Manager; Mr. D. J. Sullivan was the Principal Investigator. Special credit for assistance is due to Mr. B. B. Birkett and Mr. T. Jouhlson for their assistance in the analytic phases of the program. Mr. Jouhlson was responsible for the design, development and implementation of the prototype designs originated in this study. Mr. A. Anguelo provided the technical expertise required to implement the prototype presentation system. The authors are also particularly appreciative of the cooperation and assistance provided by the Training Aids Branch, Lowry Air Force Base, under Mr. E. Ethem.

TABLE OF CONTENTS

Page

I. Introduction 6

Purpose of the Study 6
Problem Definition 7
Related Research 8
Assumption and Clarifications 11
Approach to the Problem 13

II. Analysis of the Training Environment 25

Course Descriptions 25
Administrative and Physical Environment 33

III. Instructional Media 40

Still Transparencies 41
Still Pictures 46
Motion Pictures 48
Microforms 54
Video 60
Audio 66
Training Devices, Simulation and Real Equipment 77

IV. Media Selection Process 80

Introduction 80
Assumptions and Approach 81
Functional Requirements 84
Media Selection and Strategies 86

V. Instructional Carrel Systems Description 92

Design Parameters 93
Selected Media 94
System Description 96
Work Surface Design 102
Audio-Visual Instructional Display System 107
Instructional Carrel System Structural Configurations. . 117
Stand-Alone Presentation Devices 127
Computer Interface 129
Information Retrieval 131

TABLE OF CONTENTS (Continued)

Page

VI. Facilities 135

Still Transparency Facility 135
Photographic Print Facility 151
Motion Picture Facility 160
Microform Facility 169
Video Production Facility 175
Audio Facility 181

References 195

Glossary 200

LIST OF ILLUSTRATIONS

Page
1 A Systems Approach to Training 15
2 Study Approach 16
3 Implementation of Training Analysis Objectives 18
4 Model for Media Identification and Selection 21
5 Media/Function Match 24
6 PME Course Flow 29
7 Weapons Mechanic (TAC) Course 32
8 Noise Criteria (NC) Curves for Speech Communication . . 39
9 Inch Slide Formats 43
10 Cassette Tape Formats 70
11 Pyramid System 74
12 Model for Media Identification and Selection 83
13 Instructional Environment Components 95
14 Work Surface Dimensions 98
15 Audio Visual Instructional Display System (AIDS) 100
16 Traditional Carrel Configurations 101
17 Quad Structural Arrangement 103
18 Alternative Workspace Configuration 105
19 Study Carrel Configuration 106
20 AIDS Components 109
21 Access to Module 110
22 AIDS Controls 112
23 Alternative Audio Component Configurations 115
24 Alternative Carrel Structure Configurations 122
25 Design III/Design IV 123
26 Design V/Design VI 125
27 Design VII 126

LIST OF TABLES

1 Syllabus Summary for Present Inventory Management Course 27
2 Ventilating/Air Conditioning Capacity 35
3 Storage Requirements for Filmstrips vs Slides 45
4 Still Picture Characteristics 47
5 Comparison of Film and Electronic Camera Production . . 61
6 Separate Track Synchronization System 76
7 Comparison of Microform Characteristics 134
8 Production Cost Summary 138
9 Still-Visuals Baseline 139
10 Production Cost Data 140
11 Transparency Facility Equipment 142
12 Photographic Print Requirement 153
13 Photographic Print Costs 158
14 Motion Picture Baseline 161
15 Cost Data Associated with Motion Picture
Preparation and Distribution 166
16 Microform Facility Equipment 174
17 Video Equipment List 180
18 Audio Instructional Material Baseline 182
19 Audio Equipment Requirements 191

I. INTRODUCTION

Purpose of the Study

The study program documented in this report represents one aspect of the Air Force Advanced Instructional System (AIS) program. The AIS as presently conceived, will be a prototype computer-assisted and computer-managed instructional system which will combine and integrate the latest techniques in individualized instruction, teaching techniques, and computer technology to provide the means and the methods for the integration of the latest advances in individualized instruction. In addition to providing the Air Force with a flexible, individualized instructional system, it is intended that the initial version of AIS will also serve as a research facility to enable the continued systematic evaluation of innovations in instructional technology.

This study represents an attempt to systematically examine specified aspects of Air Force technical training, the three baseline courses, and the state-of-the-art in both instructional software and hardware. Based on these analyses, data has been synthesized into a series of recommendations for:

1. The instructional media to be used for individualized technical training.

2. The configurations of media hardware required to support individualized, self-paced instruction in the baseline courses.

3. The instructional environment best suited for the establishment and effective functioning of a program of individualized technical training.

4. The nature and functional capabilities of equipment and personnel required to support instructional software and media systems development and operation.

The systematic application of instructional innovation to obtain more effective training has occurred in various elements of the Air Force training structure. However, the rapid technological developments and varied nature of the Air Force's training mission impose a requirement for continuing systematic examination of instructional innovations and technology to determine which aspects of these technological changes would be most productive in implementing individualized instruction in Air Force technical training. The overall intent of AIS is to perform such an examination. As an integral part of AIS, the study documented in this report was commissioned for the specific intent of designing a system of instructional environments to support individualized technical training in general and AIS in particular.

Research efforts having a bearing on this study and the overall AIS program have been conducted under several different disciplines in a large number of military and civilian research programs. These efforts have been conducted divergently and sometimes even competitively, but they have been unified by a continuing concern with the present state-of-the-art in training and a conviction that the careful application of technology and the psychological principles which underlie human learning can result in improved performance, both in training and in the operational environment.

Based on analyses of the state-of-the-art in instructional technology, learning theory research, media systems, and supporting technologies, the Instructional Media and Carrel Systems Study was to identify and design a system of media, structures, and software that would facilitate the effective implementation of individualized instruction for technical training. The systems developed during this study were restrained by the parameters inherent in the present Air Force technical training environment and had to consider the impact of the AIS on both the present technical training structure and on the media system(s) that might be applied to individualized technical training programs.

Problem Definition

In the development and application of technological innovations to instructional problems, significant changes have occurred in both the approaches and the solutions to training problems. The evolution of a technology of education and training has resulted from innovations in instructional strategies and in the media of instruction.

In the rapidly developing disciplines which comprise the field of instructional technology, some of the most impressive contributions to the field have resulted from the emerging emphasis on a disciplined, process-oriented approach to the solution of instructional problems and from the application of computer technology to the management and presentation of instruction.

The program has not sprung full-blown from someone's fertile imagination, rather it represents within the Air Force the development of a concern for continual improvement of training and the tools of training. It traces its lineage through the Air Force Personnel and Training Research Center (AFPTRC), the Aerospace Medical Research Laboratory, Behavorial Sciences Branch, and most recently the Air Force Human Resources Laboratory. Throughout these years, the Air Force has continued to pursue its interest in the development and refinement of various approaches to the problems of training.

Consonant with this continued support and interest in the overall training problem, the Air Force's interest in individualized technical training has developed over a period of time, and will continue to develop in the Air Force's on-going applied research program.

This report describes the media production and associated systems required to support the media presentation systems selected for individualized technical training. In the development of any large scale instructional system, the major costs, both initial and recurring, are those associated with instructional material development, maintenance and distribution. In an individualized instructional system the problems and costs associated with materials maintenance, storage and distribution are increased by the number of copies of each item which are required, as well as the number of items required.

Related Research

The research and development efforts being performed in the conduct of this study are not isolated. They represent the latest in a continuing chain of events going back several years. Research efforts having a direct bearing on this study, our approach to it, and on the overall program to improve Air Force technical training have been conducted under several different disciplines by numerous individuals. However, they have all encompassed a single unifying theme.

That theme can be described as a continuing concern with the present state of training and education and a conviction that the careful application of technology and knowledge about human learning behavior can result in improved student performance, both in training and in the operational environment.

Two areas of research, in particular, have contributed to the development of the present understanding of the requirements of and solutions to the technical training problem.. The first of these is the research relating to what has come to be known as individualized instruction. The second area of research is much broader in scope and is best described by the general heading of instructional technology.

Individualized Instruction

The label "individualized instruction" is a relatively imprecise term for describing a host of instructional theories, techniques, and training programs. In the context of this report it is used as a descriptor for the educational, psychological and applied research that has been conducted to determine the ways and means of providing instruction to an individual with full respect for the importance of the individual differences which underlie all human learning.

Two areas of research contributing to understanding of individual differences in human learning are relevant to the design problems inherent in this study. The first of these is that body of research which has shown that the systematic examination of individual learner characteristics and the knowledges and skills to be learned must be combined with an equally systematic application of established principles of learning. This research has established the basic approach for the overall AIS program, and is also responsible for the specific approach used in this study. In addition to these applications, this research has changed the basic approach to instruction. Rather than selecting vaguely stated generalizations as to training program intent, there is now much more concern with the identification of specific, often quantitatively expressed, objectives to be attained by the learner. This research has shown that the process of designing instruction is as important as the instruction itself.

The second area of research impacting upon this study deals with the development of better means and methods for "tailoring" the type and rate of information transmission to the needs and capabilities of the individual student. In order to be effective, individualized instruction must represent more than simply providing a student with his own set of instructional materials. Effective individualized instruction can only occur in a closed-loop system in which information flow occurs both to and from the student.

Individualized instruction can take place in any number of contexts. One method is self or independent study in which the student is provided with the objectives and checkpoints which comprise his course of study. The student then sets his own standards and his own pace, deciding how much practice time he wants to spend on any given instructional sequence. In this context, the instructional environment provided to the student should be designed to facilitate student performance by providing all instructional, reference and operational materials and equipment that the student might require. In reality, the student's freedom of choice in the selection of his strategy of instruction and the means he chooses to acquire information are constrained by the media selected to store, transmit and display the information, and the knowledge and skills he is expected to acquire. Rarely, is the material to be learned available in different media forms at the same location or time.

Another form of individualized training is identifiable as "adaptive training." The primary characteristic of this instructional approach is that the strategy, presentation sequence, pacing and difficulty level are adapted for the student by some agency other than the student. In a truly adaptive system these adjustments are continuous and are made on the basis of the individual's successes and failures in responding to prior instruction. Adaptation can also be scheduled based on a prior knowledge of the students capability. Adaptive instructional strategies require successive choices among instructional alternatives as a function of learner behavior. While it is possible for an instructor to accomplish adaptive training in any training environment, the degree of adaptiveness is governed by the instructor's ability to time-share between students, blocks of instruction and between combinations of both. Truly adaptive training for more than 1 or 2 students and a limited set of instructional alternatives requires the speed, storage capacity and logical modeling capability inherent in modern computer systems.

The results of the research into the techniques, strategies and methods of individualizing instruction can be summarized as follows. Individual learning styles differ as a function of student aptitude (Bush, 1965). Learning style will also influence the communications media and symbols the student uses best. Student performance (with respect to symbol interpretation and decision-making logic associated with symbol manipulation) is influenced by cultural factors and the specific characteristics and needs of the individual students. Despite the broad range of individual differences with respect to learning behavior, it has proven possible to generalize across these differences and establish general classes or forms of instruction and media which are successful.

Instructional Technology

Instructional technology as an organized discipline is relatively new, but its roots are as old as teaching itself. It represents nothing more or less than the application of the products of existing sciences and disciplines to training. In the context of individualized technical training, and particularly of this study, instructional technology can be defined as the systematic integration of human factors research, technological innovations, learning research and the structure of the subject matter to achieve desired instructional objectives. In this context, then, the research findings that can be examined under the heading of instructional technology constitute a very wide spectrum indeed. In order to delimit that scope, it is appropriate to synthesize the great bulk of this research into a series of summary statements, describing what is presently accepted as known about instructional technology and identifying certain specific instances which represent the antecedents of this study.

The following summarization of the state-of-the-art in instructional technology research represents a synthesis of innumerable discussions between the authors, their colleagues and specifically between Mr. Sullivan and Dr. William H. Allen and Dr. Robert Casey of the Instructional Technology Department, Graduate School of Education, University of Southern California. Dr. Allen has developed similar status reports on the research in instructional technology at several points in the last twelve years (Allen, 1959, 1968, 1971).

1. Communication of Factual Information. Mediated forms of instruction convey factual information content at least as effectively as the presently used lecture method.

In about 85 percent of the studies comparing motion pictures with classroom instruction, films were found to be significantly more effective as the means of instruction.

"Filmstrips and slides appear to be at least as effective as motion pictures in teaching factual information." (Allen 1959) This finding seems to stem from the fact that these media are the best suited for individual pacing and offer the widest latitude for student participation.

2. Teaching Psycho-Motor Skills. Both film-based media and video are effective as instructional tools in the development of psychomotor skills; they are just as effective as the conventional lecture/demonstration method.

Careful attention to the preparation of software is extremely vital to the success of mediated instruction for this type of application. Only through the provision of actual participation by the learner can the real potential of mediated psycho-motor skill instruction be realized.

3. Relationship of Learner Characteristics to Media Use. It can be inferred from almost all media related research, and from some more directly related efforts (Salomon & Snow, 1968), that a definite interrelationship exists between learner characteristics and media characteristics. Salomon and Snow state that "one should expect interaction effects between particular media attributes, learner traits and learning objectives." This concept, which can be labeled aptitude treatment interaction (ATI), represents the real crux in the selection of instructional media, and as such, is presently a deficiency in the discipline of instructional technology. Aptitude treatment interactions exist and they are certainly the determinants of media applicability and success; however, the research has not yet succeeded in identifying or labeling even general classes of ATI's. Allen (1967), Bretz (1969), Brigg's (1967), Fleishman (1968), Parker and Downs (1961) and Rhode (1970), among others, have attempted to develop rationales for the selection of training media, but almost all have ignored the ATI problem, preferring to stay with the simpler dimensions of cost and/or stimulus characteristics.

The "environment" in which mediated instruction is presented has a definite impact on the learners attitude toward that instruction and thus upon its effectiveness as a training tool. Environment, as used here, connotes not only the immediate physical surrounding for the media, but also the attitude of the learner as developed by administrative constraints, etc.

Assumptions and Clarifications

Certain assumptions must be made to establish a functional baseline upon which the media development facility can be based.

1. All production cycles for media described in this report are assumed to begin with completed scripts, graphic art and textual frames already developed and ready for inclusion in the instructional production.

2. The media production facility, as described herein, is a functional rather than a physical configuration. When layouts or space requirements are identified, they are specific to the functional capability under discussion rather than representing a space in some existing building.

3. Costs, unless otherwise identified, represent only the material and production cost associated with a specific function. The cost of a filmstrip, for example, is defined as the cost of producing the master and then the copy cost per filmstrip of the raw stock, processing, and packaging. No attempt at amortization of hardware and/or facilities costs has been attempted, nor has the cost of script generation or graphics preparation been included when costing specific media requirements.

4. Personnel costs are estimates and do not reflect exact salary rates for any grade level or type of individual.

5. Minor assistance to these functions will be required in several forms, all of which are sufficiently diverse in nature and fragmentary in amount and scheduling of time that they cannot be combined efficiently. This assistance would take the form of transportation (driver), production assistance (setting up equipment or props, etc.) and finishing assistance (cartridge or cassette loading, labeling, etc.). Since some of this same type of assistance is required in all of the production facilities described in this report, it is anticipated that the demand is sufficient to support one to two individuals in each of these functions.

6. In order to develop staffing and organizational structures which are clearly definable, the following rationale has been developed with respect to the overall instructional materials development organization for technical training.

This organization (strictly hypothetical at this point) is an organizational element under the technical training school director. It has one and only one function: to support the development of individualized instructional materials in certain specified media and formats. It is composed of three major functional entities: (a) planning and control, (b) instructional development, and (c) production.

The planning department provides administrative and technical control over the total organization and provides an individual to serve as producer/director for each instructional package assigned to the organization. The instructional development department would consist of the training specialists, writers, instructional development specialists, etc. On any given package they would provide individuals to develop the scripts and/or story boards. The production department is the department primarily addressed within this report. It consists of several smaller organizations each charged with specific responsibility for media production.

The assumed mode of operation for the overall instructional materials development (IMD) organization is as follows: The requirement for an instructional package is identified within a specific course (precision measurement equipment specialist for example) by the instructional staff. The planning and control department of IMD receives the objectives the instructors wish the instructional package to achieve. Planning and control assigns an individual to direct the development of this package. In concert with the instructor(s) from the course and the writer(s) assigned by the instructional development department the director clarifies the objectives of the package and develops a story outline. This story outline is expanded by the writer and instructor into a script identifying the requirements for narration, sound effects, graphics and live action sequences. The completed script is presented for review to the specific course or training department and to the technical sections of IMD. The approved script is scheduled into the required production departments for production and implementation.

This report is concerned with the staffing, facilities, and equipment requirements of the production departments covered. The hypothetical organization and operation were established only to provide a structure within which the production departments would function. The main features recommended for production operations are: (a) administrative and creative direction is external to the production department, (b) all production proceeds from firmly established scripts/story-boards, and (c) the instructor(s) is the technical consultant throughout the development and production process.

Approach to the Problem

The overall goals of this study were to develop a series of recommendations and functional carrel system configurations that would be capable of supporting the operation of Air Force technical training as individually paced, self instructional programs. Specifically, the objectives were:

1. Perform an analysis of the present state-of-the-art in instructional media. Identify and define the characteristics of presently available media and media presentation systems and hardware. Identify trends and development in instructional media and systems which would influence the types of media and instruction used in a program of individualized technical training.

2. Design a system of instructional environments for individual study in technical training subjects. The instructional environment was initially conceived of as a family of instructional carrels and related training areas. The system is required to provide for at least remedial instruction, reference material and some performance of activities in addition to individual study.

3. Design a media production system to support the instructional environments developed in this study. This system of hardware and facilities must include all of the items required for the production, processing, reproduction, packaging and distribution of instructional sequences in all selected media.

The approach to the attainment of these objectives in the development of an effective instructional environment was through analysis of functional requirements, identification of constraints, selection of alternative solutions and selection of optimal solutions.

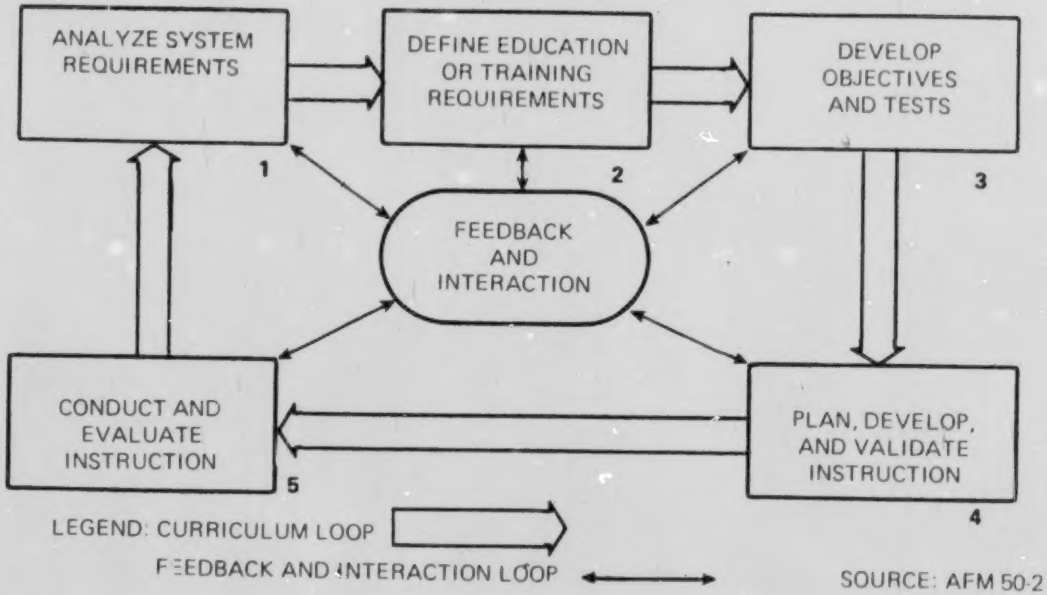
Considered as an integrated whole, these steps constitute the basis for what has come to be known as the "systems approach" or the "instructional systems development" approach (Fig. 1). Eckstrand (1964) defined the systems approach to training as a logical flow of events culminating in the production of trained personnel. One of the important aspects of this conceptual approach to training design is the necessity for identifying the interactions between elements of the instructional sequence.

A representation of our approach to this study is provided by Figure 2. The systematic, iterative approach delineated in Figure 2 is representative of the logical approach to any design problem; in this study it has been applied as a proven approach to the problem of developing an instructional environment for each of the three baseline courses which comprise AIS.

There are three aspects of this approach to instructional systems design which require particular attention in order to ensure the development of an effective solution. These are: (a) training objective definition, (b) establishment of media effectiveness, and (c) media selection.

Definition of Training Objective

Once the goal of the overall analysis and design program was established, the first major task to be accomplished by the study team was identical to that required in the design of any instructional system; the establishment of the specific objectives for which the system must be designed to train. The definition of the instructional objectives required the use of task analysis, to establish answers to the following questions:


ANALYZE SYSTEM REQUIREMENTS
1
DEFINE EDUCATION OR TRAINING REQUIREMENTS
2
DEVELOP OBJECTIVES AND TESTS
3
FEEDBACK AND INTERACTION
CONDUCT AND EVALUATE INSTRUCTION
5
PLAN, DEVELOP, AND VALIDATE INSTRUCTION
4
LEGEND: CURRICULUM LOOP
FEEDBACK AND INTERACTION LOOP

SOURCE: AFM 50-2

Figure 1. A systems approach to training.

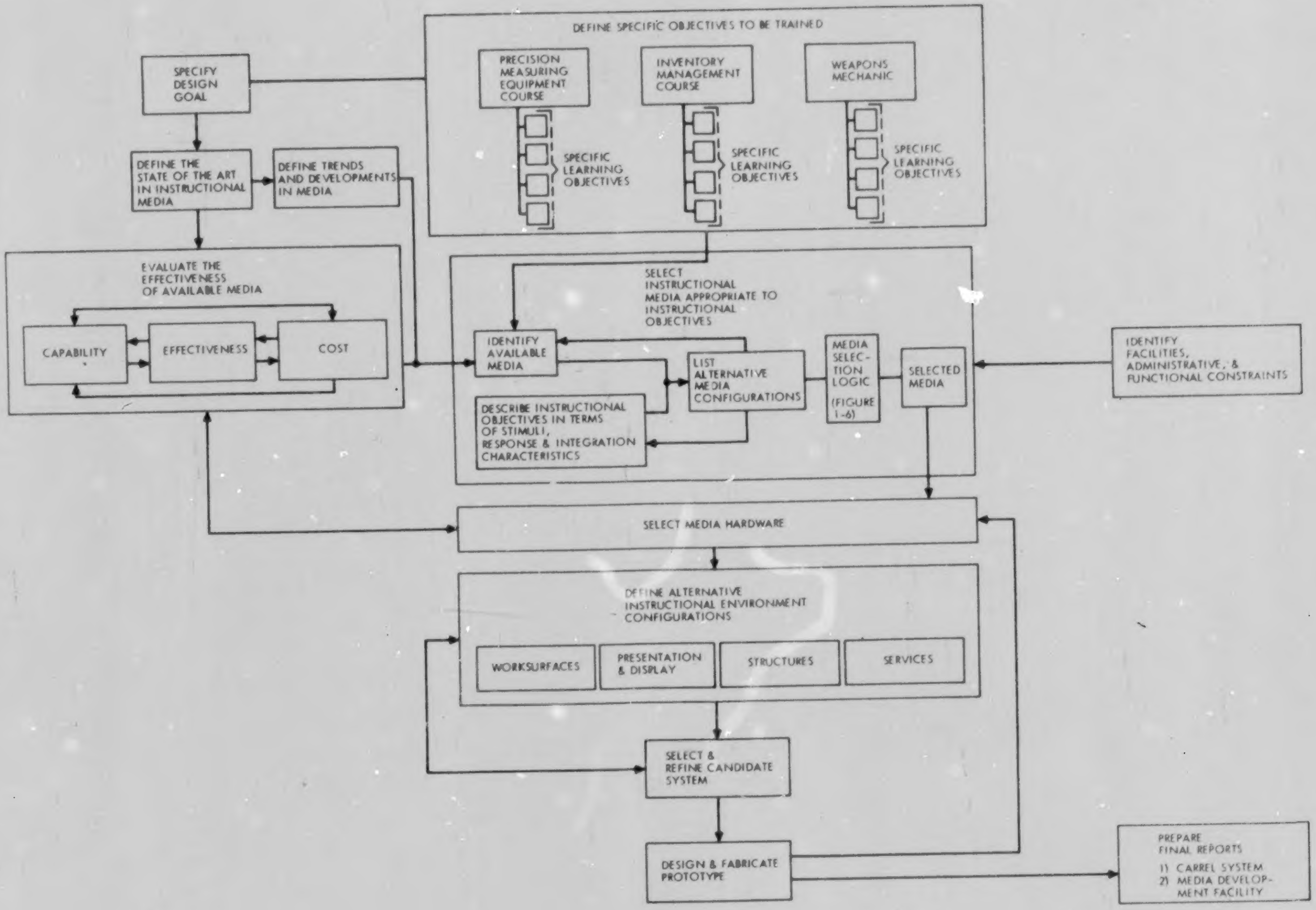

SPECIFY DESIGN GOAL
DEFINE THE STATE OF THE ART IN INSTRUCTIONAL MEDIA
DEFINE TRENDS AND DEVELOPMENTS IN MEDIA
DEFINE SPECIFIC OBJECTIVES TO BE TRAINED
PRECISION MEASURING EQUIPMENT COURSE
SPECIFIC LEARNING OBJECTIVES
INVENTORY MANAGEMENT COURSE
SPECIFIC LEARNING OBJECTIVES
WEAPONS MECHANIC
SPECIFIC LEARNING OBJECTIVES
EVALUATE THE EFFECTIVENESS OF AVAILABLE MEDIA
CAPABILITY
EFFECTIVENESS
COST
SELECT INSTRUCTIONAL MEDIA APPROPRIATE TO INSTRUCTIONAL OBJECTIVES
IDENTIFY AVAILABLE MEDIA
DESCRIBE INSTRUCTIONAL OBJECTIVES IN TERMS OF STIMULI, RESPONSE & INTEGRATION CHARACTERISTICS
LIST ALTERNATIVE MEDIA CONFIGURATIONS
MEDIA SELECTION LOGIC (FIGURE 1-6)
SELECTED MEDIA
IDENTIFY FACILITIES, ADMINISTRATIVE, & FUNCTIONAL CONSTRAINTS
SELECT MEDIA HARDWARE
DEFINE ALTERNATIVE INSTRUCTIONAL ENVIRONMENT CONFIGURATIONS
WORKSURFACES
PRESENTATION & DISPLAY
STRUCTURES
SERVICES
SELECT & REFINE CANDIDATE SYSTEM
DESIGN & FABRICATE PROTOTYPE
PREPARE FINAL REPORTS
1) CARREL SYSTEM
2) MEDIA DEVELOPMENT FACILITY

Figure 2. Study approach.

1. What are the objectives of the training program?

2. In terms of identifiable functions and discrete tasks, what skills must be mastered by the trainee and what knowledges must he acquire?

3. What objective performance measures indicate trainee achievement on each skill component?

4. What objective performance measures can serve as indicators of trainee learning problems?

5. What is currently being trained?

6. How is it being trained?

7. What are typical trainee problems historically associated with the learning of each skill required?

In addition to these questions about the existing or proposed training program, a second set of questions about training techniques or instructional strategies must also be answered. These questions include:

1. What knowledges and skills are related and can be functionally grouped?

2. What are the best means of teaching each of these task groupings?

3. Where is individual instruction necessary?

4. What improvements are required in training content and training equipment capability in order to most effectively achieve the objectives of the training program?

The flow presented in Figure 3 depicts the order and relationship of specific tasks that need to be performed in order to complete an adequate training analysis. The level of specificity in a training analysis should be sufficient to allow: (a) the combination of related tasks into meaningful training units; (b) definition of performance associated with the successful accomplishment of training units, specific functions or tasks; and (c) definition of specific task requirements impacting individualized instruction.

The efficacy of this approach to the establishment of instructional system objectives has been spelled out by several researchers (Carpenter, 1970; Meister, 1971; Kaufman, 1964 are examples) and the approach is an integral part of the ISD approach spelled out in AFM 50-2 (1970).

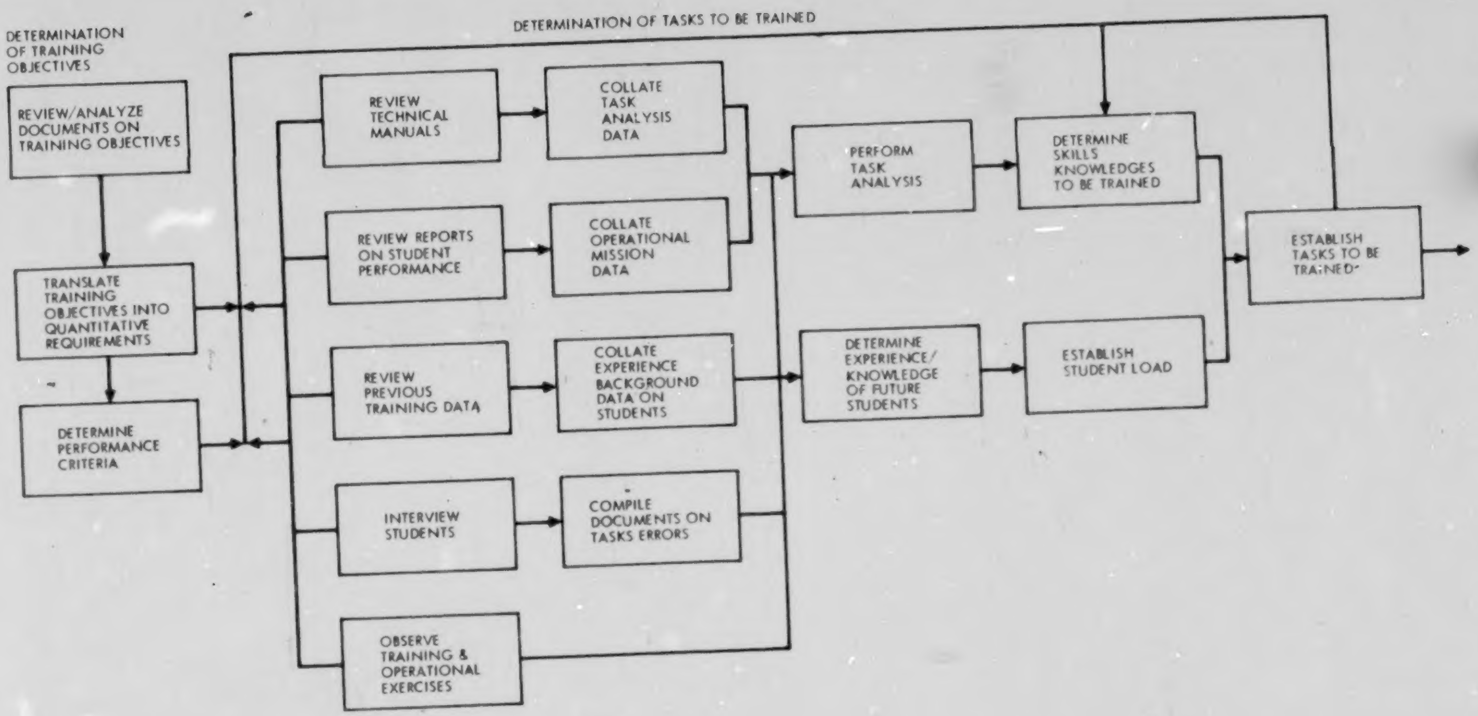

DETERMINATION OF TRAINING OBJECTIVES
REVIEW/ANALYZE DOCUMENTS ON TRAINING OBJECTIVES
TRANSLATE TRAINING OBJECTIVES INTO QUANTITATIVE REQUIREMENTS
DETERMINE PERFORMANCE CRITERIA
DETERMINATION OF TASKS TO BE TRAINED
REVIEW TECHNICAL MANUALS
REVIEW REPORTS ON STUDENT PERFORMANCE
REVIEW PREVIOUS TRAINING DATA
INTERVIEW STUDENTS
OBSERVE TRAINING & OPERATIONAL EXERCISES
COLLATE TASK ANALYSIS DATA
COLLATE OPERATIONAL MISSION DATA
COLLATE EXPERIENCE BACKGROUND DATA ON STUDENTS
COMPILE DOCUMENTS ON TASKS ERRORS
PERFORM TASK ANALYSIS
DETERMINE EXPERIENCE/ KNOWLEDGE OF FUTURE STUDENTS
DETERMINE SKILLS KNOWLEDGES TO BE TRAINED
ESTABLISH STUDENT LOAD
ESTABLISH TASKS TO BE TRAINED

Figure 3. Implementation of training analysis objectives.

Determination of Media Effectiveness

In determining the appropriate media for a particular subject matter, three interrelated criteria were used. The first criterion related to the capacity of a medium to display relevant stimuli to which appropriate responses can be made.

A pragmatic approach would lead to the selection of the medium with the minimum capability to do the job. This approach would leave more complex media available for more suitable jobs, and it would also tend to be the most economical approach, since complexity of capability and cost are directly related. The second consideration relates to the capacity of the medium to facilitate correct responding. Cost considerations, the third criterion, enter only after these performance considerations were determined. Judgments about media found equally capable in terms of the first two achievement criteria were based finally on economic considerations.

This selection method represents the optimum way of making decisions about media utilization. In any practical situation, all three sets of criteria were considered jointly. Compromises and tradeoffs were found necessary. These included the desire to make full use of media already paid for and available rather than acquiring new media facilities, and the administrative convenience made possible through the use of one medium rather than another. Compromises in media selection, in some cases, resulted in under-or-over-utilization of a medium.

A medium is under-utilized when it is used to display stimuli which a medium of less complex capabilities can handle. If available, and if there is the desire to make fuller use of the more complex medium, it is possible to use the more-complex-than-necessary medium for the simpler job. It may be used, however, only so long as it brings with it no liabilities.

Over-utilization arises when a medium of simple capabilities is expected to do a job requiring far more complex capabilities. Over-utilization appears to be the far more serious problem to the educator because it is likely to result in unacceptable standards of achievement.

Since training media and devices account for a major part of the capital expenditures associated with training program implementation, the economic consequences of inappropriate decisions warrant extremely careful research and analysis prior to selection and specification. Costs associated with media and device selection must be measured not only in terms of dollars but in terms of:

1. The time required for implementation and effective operation.

2. The requirements for additional instruction and support manpower.

3. Impact upon present manpower in terms of additional training, changed workload, and restructured roles.

4. Remodeling or obsolescence of present equipment and facilities.

5. Operations and maintenance costs after initial investment has been made.

In selecting the media and media presentation equipment for a technical training environment several dimensions are of particular concern. These are: (a) the stimulus presentation capabilities of the media, (b) "effectiveness" of the media, and (c) the degree of "transfer" inherent in the media.

1. Stimulus Presentation. As can be seen in Figure 4, which is a simplified model of the media selection process, one of the initial steps in determining media to be considered for a particular training application is to determine what stimuli can be presented by what media. The critical aspect of this step is the description or classification of the available media in terms of the stimulus dimensions they can present. Media may affect only a single sense (as in an audio tape) or a combination of senses (as in a simulator). The real object or actual work situation can, of course, be perceived by any or all senses. The value of media over the real situation is that it allows the manipulation of size, time, distance, focuses attention and controls the amount of information presented at a given time. Judicious use of these media characteristics facilitates learning by pacing and controlling information transfer to a rate consonant with the level of learning which is taking place.

2. Media Effectiveness. Once the available media have been identified, the next logical question to ask is: Which of these is most effective? This is a relatively simple question, one which is, however, extremely difficult to answer - particularly when the desired answer is a straightforward list. The empirical evidence available is meager and must be interpreted in terms of the stimulus and response requirements imposed by a given function/task; once it has been determined that the available media can fulfill the stimuli presentation, response compatibility, and feedback requirements, then they may be examined as to their effectiveness.

A given medium is more effective than an alternate if it:

1. Reduces the length of time needed to achieve the same level of student proficiency.

2. Increases the degree of proficiency achieved by students without increasing the training time.

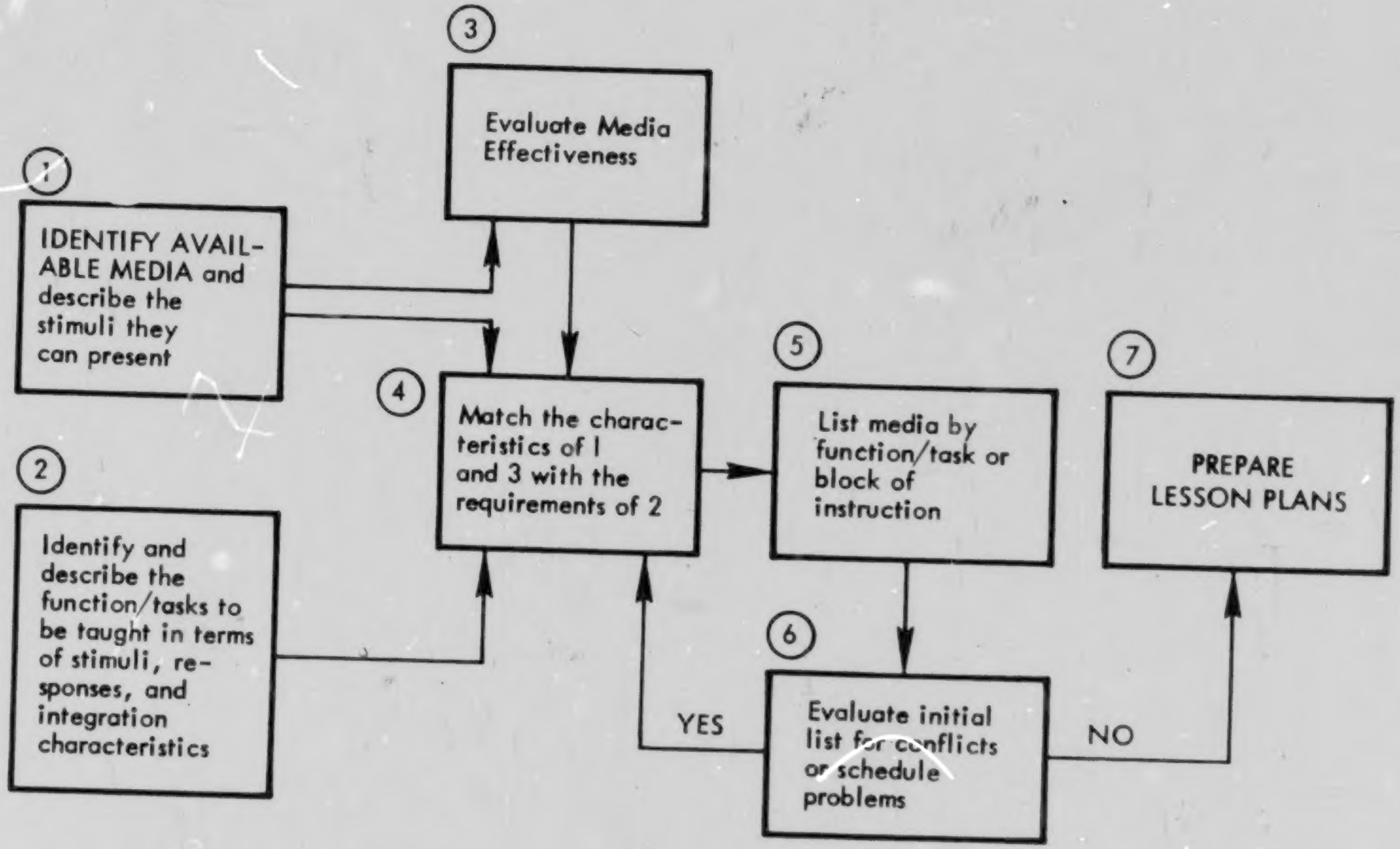

1
IDENTIFY AVAILABLE MEDIA and describe the stimuli they can present
2
Identify and describe the function/tasks to be taught in terms of stimuli, responses, and integration characteristics
3
Evaluate Media Effectiveness
4
Match the characteristics of 1 and 3 with the requirements of 2
5
List media by function/task or block of instruction
6
Evaluate initial list for conflicts or schedule problems
YES
NO
7
PREPARE LESSON PLANS

Figure 4. Model for media identification and selection.

3. Increases the number or range of students who can be trained concurrently or sequentially beyond that permitted by the comparison media.

4. Reduces the instructor-student or equipment-student ratio below that required by the comparison media.

These are the basic criteria of training effectiveness. Also to be considered is the fact that where there are no substantial training effectiveness differences between available media/aids, but one costs less than another, the less expensive device can be considered to be more desirable on a cost-effectiveness basis. Because of the lack of substantial data on training effectiveness, and because of the real world constraints within which a training program must operate, it can be seen that many of the decision comparisons between alternative media must be made on the basis of cost-effectiveness.

3. Transfer of Training. Another dimension which must be considered in the selection of a training medium is the extent to which it facilitates the transfer of a learned skill or task to the operational environment. Transfer is not only a function of media, but also of the various tasks which the medium trains. There are two criteria of transfer which should be kept in mind:

1. The degree to which instruction in one function/task will facilitate the learning of another task.

2. The degree to which the learning of a given task will generalize to performance of the same function/task in a different context - that is transfer to the operational environment.

Media Selection Process

The supposition underlying the application of the analytic techniques described in this report is that different functions/activities and/or training objectives implicitly require different sets of learning conditions, and that certain media will serve as better sources of those conditions than others. Operating under the law of parsimony, only those media which are just sufficient to meet anticipated requirements with maximum economy would be used, and then only to the extent that their particular characteristics relate to the behaviors being trained. This is not meant to imply that there is any single medium which would be the optimal means of instruction, rather, a media-mix is hypothesized which would provide the highest attainable level of instructional effectiveness for the objectives to be trained.

The processess required to realize the goal of the foregoing statement are:

1. Evaluate the comparative effectiveness of each medium under varying conditions (utilizing the media effectiveness criteria discussed earlier).

2. Determine the performance requirements of each function in a manner which is relatable to discriminable media characteristics ("discriminable" in a sense that the classroom, for example, is differentiated from the simulator).

These processes describe two sets of analyses which will be termed:

1. Media Analysis and
2. Function Analysis.

It is the synthesis of these two analyses (shown in Figure 5) which indicate the effectiveness of each medium for each function or block of instruction to be trained.

Hardware and Facilities

Having determined the media-mix required to support individualized technical training, the necessary production, processing, reproduction, packaging, and distribution functions associated with each of these media were identified along with alternative means for satisfying these functional requirements. From this list, optimal alternatives for each functional requirement have been isolated and are delineated in the remaining sections of this report. The specific types of equipment and processes involved, lie in the grey area between a highly regulated government market and a totally unregulated consumer market. The materials, equipment, and processes used in media production are a mixture of professional, service and consumer-oriented goods and services. Control of quality, cost, and to a certain extent demand, resides with those individuals and organizations performing the work. Consequently, the acquisition of unbiased or even objective performance data is extremely difficult. The criteria to distinguish between alternatives varies from requirement to requirement. In most instances the recommendations presented in this report represent a consensus of expert judgments supplemented by specific data on such factors as initial and operating costs, and professional reputation of a given product or process.

This report documents the results of these analyses and judgments. The intent is to identify the functional characteristics of equipment, facilities and processes required to satisfy requirements for the quantity and quality of media production necessary to support individualized technical training on the scale predicted under the AIS program. Where functional characteristics are only definable in terms of a specific piece of equipment or proprietary process, that equipment or process is identified. This does not constitute an endorsement by either the Air Force or Hughes Aircraft, but is done to enhance the clarity of this report.

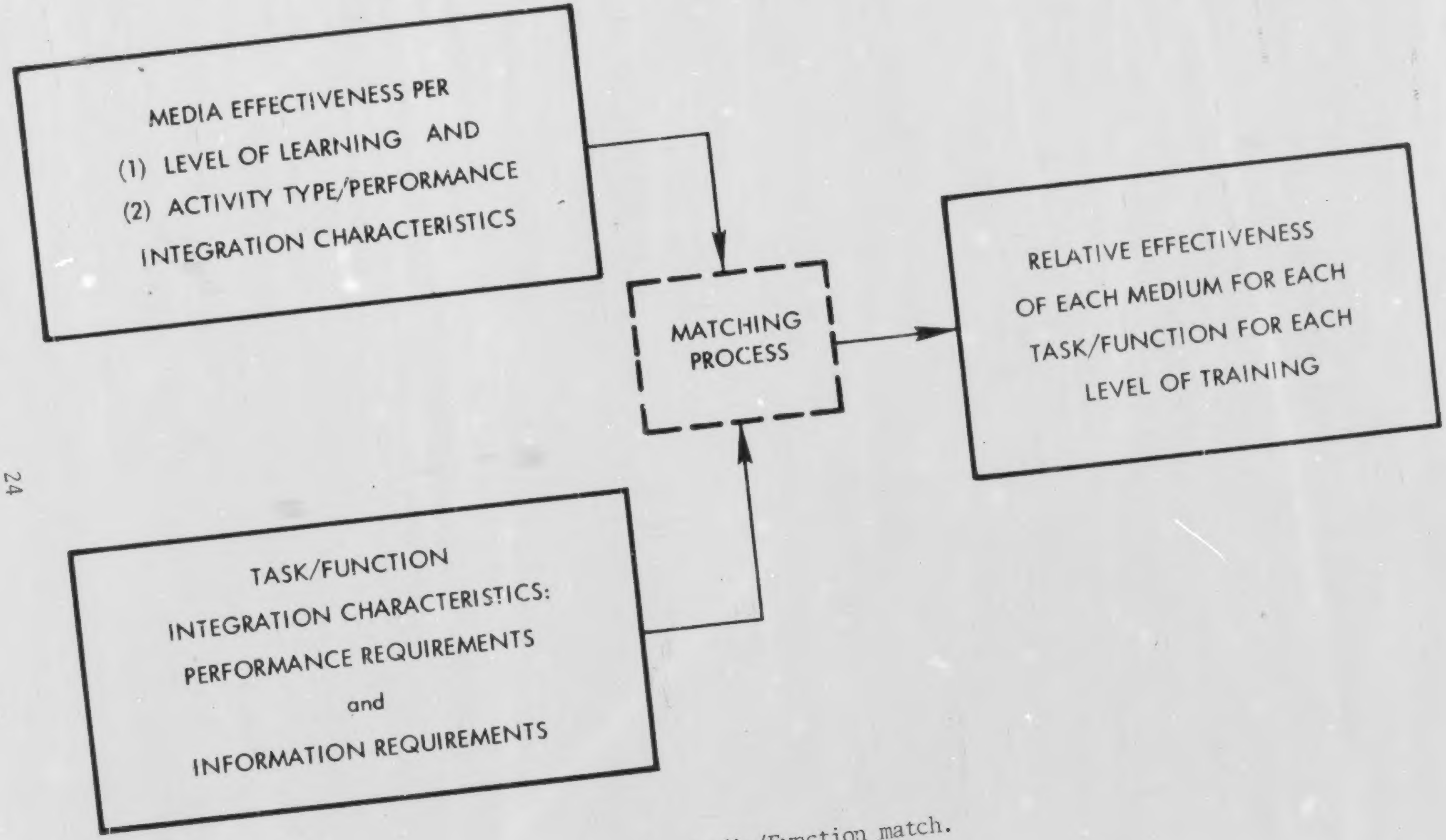

MEDIA EFFECTIVENESS PER
(1) LEVEL OF LEARNING AND
(2) ACTIVITY TYPE/PERFORMANCE
INTEGRATION CHARACTERISTICS
MATCHING PROCESS
RELATIVE EFFECTIVENESS OF EACH MEDIUM FOR EACH TASK/FUNCTION FOR EACH LEVEL OF TRAINING
TASK/FUNCTION
INTEGRATION CHARACTERISTICS:
PERFORMANCE REQUIREMENTS
and
INFORMATION REQUIREMENTS

Figure 5. Media/Function match.

II. ANALYSIS OF THE TRAINING ENVIRONMENT

The initial step in approaching the design of any instructional system is the performance of an analysis of what is to be trained. In the case of this study, what is to be trained has been defined by the specification of the three baseline courses: Inventory management specialist, weapons mechanic (TAC) and precision measuring equipment specialist. In approaching the specific goals of this study, it was also necessary that the what and how of these baseline courses be identified and analyzed to determine the influence of such factors as availability of present training equipment and other aids, student/instructor ratios, student load and flow, student input characteristics, scheduling of classes and materials, and other administrative constraints operating in the training environment.

In addition, the physical environment in which these courses will operate was analyzed to determine if it imposed any constraints on initial instructional system configuration or upon large scale implementation of the mediated instructional concept.

In the following pages the three baseline courses are described, and the administrative and physical environments are examined.

Course Descriptions

In pursuing the development of AIS, the Air Force has selected three ATC courses for initial conversion from the existing instructional system to one based on individualized, mediated instruction. The criteria established for baseline course selection included the following: (a) course(s) should have a continuous, stable, and fairly large student flow, (b) course(s) selected should contain functional characteristics generalizable to other training programs, (c) course(s) selected should involve the spectrum of training found in Air Force technical training, and (d) course(s) selected should involve individual skill development, and small team training.

Three ATC courses (inventory management specialist, precision measurement equipment specialist and weapons mechanic (TAC) were selected as collectively representing the spectrum of technical training in the Air Force. While the combination of the three baseline courses represents a large percentage of the generic types of tasks and functions to be learned in Air Force technical training, they are different from each other. Inventory management stresses information acquisition, rote procedures and clerical skills; the precision measuring equipment specialist course includes extensive cognitive skill mastery, development of fine psycho-motor skills and mastery of complex procedures; while the weapons mechanic course stresses gross psycho-motor learning and team training.

The proper development of an instructional environment, requires that the behaviorial objectives, types of learning and specific instructional events for each course be identified and analyzed. The approach developed here is based on the thorough definition of what is to be trained. While there are several different methods for performing analyses of the objectives, events, and environment of any training system, it has been found that breaking out the specific functions and activities to be trained provides the instructional system developer with the most accurate rendition of what needs to be trained (AFM 50-2). The level of detail required of any such analysis is, and should be, adjusted to the goals of the development effort. Hence, the level of detail one seeks in developing course material for a specific plan of instruction (POI) is much greater than that sought for the development of the syllabus for the total course.

The purpose of this study was to develop the instructional environments required to support individualized technical training. A level of analysis was selected which provided the proper amount of information for media and strategy selection without providing unnecessary detail. In the following pages the three baseline courses are described and their salient characteristics with respect to media selection and instructional facilities design are identified.

Inventory Management Specialist Course

The Inventory Management Specialist course, as presently structured, is designed to provide two types of skills to its students; the first of these skills is an understanding of the relationship between various aspects of the Air Force supply system and the types of data required to allow the supply system to function. The second skill provided by the course is a mastery of the procedures required to operate the supply system; e.g., what forms are used, where the data goes on the form, from where is the data acquired, etc. Considering the nature of the procedures and skills associated with successful completion of the Inventory Management course, one can describe the overall course as being "clerical" in nature, in the sense that the bulk of the skills mastered pertain to the proper completion of the form(s) appropriate to particular supply situations. The course is composed of four major blocks; the block and lesson headings for the course are listed in Table 1.

Since the type of training being provided is almost totally clerical in nature, its conversion to individualized forms of mediated instruction presents relatively simple demands in terms of media selection and instructional facilities design. Based upon our analysis, it would be possible to convert the entire Inventory Management course to self-instructional form. This conversion (including programmed texts and other media) would allow instruction to be both more effective and efficient.

Table 1. Syllabus Summary for Present Inventory Management Course

BLOCK I - General and Research	60 Hours	Orientation (2 hrs); Airman Supply Career Field (2 hrs); Communications Security (4 hrs); USAF Supply System (5 hrs); Air Force Stock Fund (3 hrs); USAF Supply Manual (5 hrs); Master Cross Reference List (3 hrs); Illustrated Parts Breakdown (3 hrs); Cataloging Handbooks (3 hrs); USAF Federal Supply Catalogs (12 hrs); USAF Interchangeable and Substitute Grouping Stock Lists (4 hrs); Index of Cataloging Publications (2 hrs); Research Functions (7 hrs); Measurement (3 hrs); Critique (2 hrs).
BLOCK II - Item Accounting and Maintenance Support	60 Hours	Standard Base Supply System (4 hrs); Internal and External Records (5 hrs); File Maintenance Procedures (8 hrs); Remote Operations (3 hrs); Supplies Issue Procedures (6 hrs); Repair Cycle and DIFM Control (8 hrs); Rejects and Inquiries (4 hrs); Bench Stock (4 hrs); Supplies Inventory (5 hrs); Item Accounting and Maintenance Support Functions (8 hrs); Measurement (3 hrs); Critique (2 hrs).
BLOCK III - Stock Control	60 Hours	Stock Control Levels (4 hrs); Initial Spares Support Lists (2 hrs); MILSTRIP Requisitions (6 hrs); MILSTRIP Related Products (3 hrs); Base Procurement (6 hrs); Due-Out Revalidation and Due-In Reconciliation (3 hrs); Materiel Control (3 hrs); Monitoring Priority Requirements (5 hrs); Receipts and Due-Out Releases (4 hrs); Stock Balance and Consumption Reports (3 hrs); Base Excesses (3 hrs); Shipments and Transfers (4 hrs); Document Control (2 hrs); Stock Control Functions (6 hrs); Measurement (3 hrs); Manual Accounting (2 hrs); Critique (1 hr).
BLOCK IV - Equipment Management	60 Hours	Air Force Equipment Management (3 hrs); Allowance Documents (3 hrs); Authorization Procedures (6 hrs); EAID Records (6 hrs); Equipment Issue Procedures (3 hrs); Equipment Turn-In Procedures (3 hrs); Adjusting EAID Records (3 hrs); Intercustody Transfers (3 hrs); REM Procedures (6 hrs); Reports and Special Procedures (3 hrs); Equipment Inventories (3 hrs); Individual Equipment and Tool Issue Procedures (6 hrs); Equipment Management Functions (6 hrs); Measurement (3 hrs); Critique (2 hrs); Graduation (1 hr).

Under an individualized approach to instruction, responsibility for student understanding, progress, pacing and course completion shifts from the lesson instructor to the student and to those responsible for media preparation. Acceptance by supply department administration would represent the first step in the conversion of inventory management to an individualized program of instruction. To an extent, this has already been accomplished through the use of programmed texts in various blocks of the course (specifically in Block I - Section 2, Block II - Sections 5 and 9 and Block IV - Sections 10 and 12). Building upon the demonstrated capability of individually paced printed materials to assume the burden of instruction within the previously cited blocks, and pursuing our basic concept of improved instruction through complementary multi-channel presentations, it appears safe to conclude that the entire inventory management course could be converted to individualized, mediated instruction.

Selection of the media required to support such a program of individualized instruction is covered in this report.

Precision Measuring Equipment Specialist

The PME course represents a much tougher challenge for the development of individualized mediated instruction. It requires student learning at almost every level: affective, perceptual, cognitive and psychomotor. The course must convert technically unsophisticated students into one of the most proficient and skilled classes of technician in the Air Force. Thus, the depth and breadth of training required imposes a heavy burden on the instructional developer, even without the problem of mediation.

The course is composed of 15 blocks of instruction divided into 2 areas. The first several blocks concentrate on the fundamentals of mathematics, physics, and electronics; the second area, consisting of blocks 8-15, is concerned with actual measurement and calibration procedures. While the emphasis during blocks 8-15 is on hands-on training, review and emphasis are also given to basic principles. Figure 6 lists the title and duration of each block of instruction.

Analysis of the content, present methods of instruction, and the objectives of the PME course, leads to the conclusion that more extensive use of mediated, individualized instruction would be both feasible and effective. Attempts at individualization have already been made in the present PME course. These attempts have taken two separate tracks:

1. The extensive use of student work books and study guides, which are used from Block 1 on.

2. The use of self-paced audio-visual instruction in Block 7 of the present course.

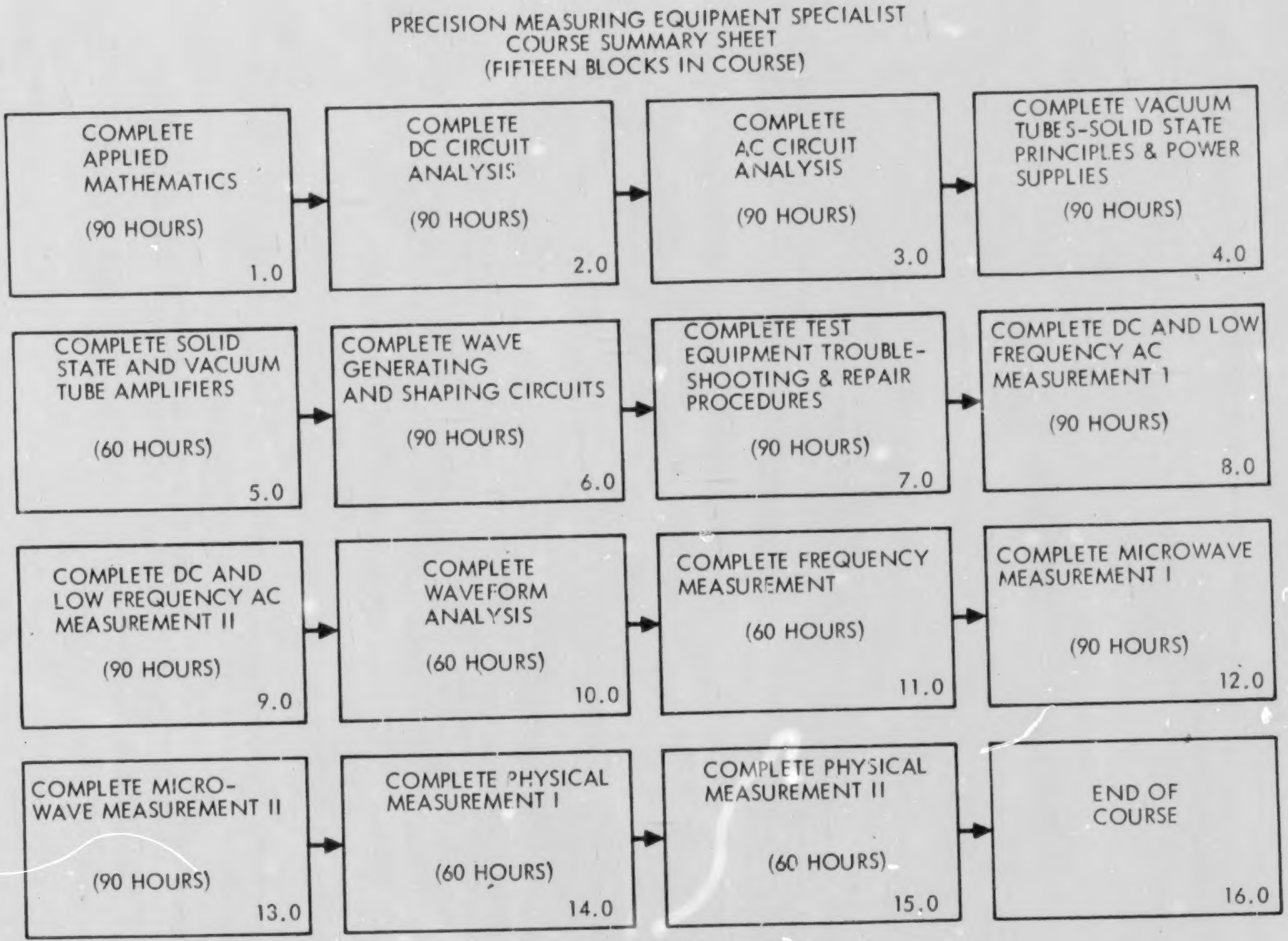

PRECISION MEASURING EQUIPMENT SPECIALIST
COURSE SUMMARY SHEET
(FIFTEEN BLOCKS IN COURSE)
COMPLETE APPLIED MATHEMATICS (90 HOURS) 1.0
COMPLETE DC CIRCUIT ANALYSIS (90 HOURS) 2.0
COMPLETE AC CIRCUIT ANALYSIS (90 HOURS) 3.0
COMPLETE VACUUM TUBES-SOLID STATE PRINCIPLES & POWER SUPPLIES (90 HOURS) 4.0
COMPLETE SOLID STATE AND VACUUM TUBE AMPLIFIERS (60 HOURS) 5.0
COMPLETE WAVE GENERATING AND SHAPING CIRCUITS (90 HOURS) 6.0
COMPLETE TEST EQUIPMENT TROUBLESHOOTING & REPAIR PROCEDURES (90 HOURS) 7.0
COMPLETE DC AND LOW FREQUENCY AC MEASUREMENT 1 (90 HOURS) 8.0
COMPLETE DC AND LOW FREQUENCY AC MEASUREMENT II (90 HOURS) 9.0
COMPLETE WAVEFORM ANALYSIS (60 HOURS) 10.0
COMPLETE FREQUENCY MEASUREMENT (60 HOURS) 11.0
COMPLETE MICROWAVE MEASUREMENT I (90 HOURS) 12.0
COMPLETE MICROWAVE MEASUREMENT II (90 HOURS) 13.0
COMPLETE PHYSICAL MEASUREMENT I (60 HOURS) 14.0
COMPLETE PHYSICAL MEASUREMENT II (60 HOURS) 15.0
END OF COURSE 16.0

Figure 6. PME course flow.

McDonnell-Douglas (Lewis et al., 1971) in their preliminary analysis of the PME course selected six of the present blocks of instruction (specifically Blocks 3, 4, 6, 10, 13 and 15) as being particularly suitable for conversion to individualized, mediated instruction. Our independent analysis of the course indicates that Blocks 1-7, being primarily at the conceptual and factual learning levels, could be converted/supported almost entirely by individualized, mediated instruction. In Blocks 8-15 the major emphasis is on hands-on performance and the development of mediated instructional packages represents a much more severe challenge.

It can be concluded from the available research and performance data on mediated technical training that the primary contribution that can be made to the PME course would be the development of an environment in which the student is introduced to the knowledge or skill content of a specific lesson or block with the presentation media servicing that specific instructional segment forming an integral portion of the environment. Depending on the presentation media selected, it would be desirable that the environment designed for PME instruction be flexible enough to support the display of remedial instruction or reference materials during the practical training segments.

The PME course represents an extremely complex mixture of cognitive, psychomotor, and perceptual learning. In the early phases (the first seven blocks) of this course, emphasis is given primarily to the students' comprehension and understanding of the computational and logical structures of mathematics and college level physics. This type of learning behavior requires carefully paced and well visualized presentations of abstract principles and concepts. In the latter phases of this course, emphasis shifts to the development of correct procedural behavior on the part of individuals and two-man teams in applying previously learned concepts and principles to relatively fine psychomotor tasks. The requirements imposed by such a mixture in terms of media development and utilization are severe enough that no single medium could be expected to adequately support the entire program of instruction. In order to specify the proper media mix for PME, each block's particular characteristics need to be considered with respect to stimulus characteristics, difficulty, duration, etc.

Weapons Mechanic (TAC)

The weapons mechanic course requires the mastery of three major categories of learning with emphasis on procedural and gross psychomotor task mastery as opposed to the development of extensive conceptual skills. Emphasis, in terms of course time and instructor judgment, must be given over to the training of gross psychomotor skills for individuals operating independently and as members of a two or four man team. The largest volume of training time is devoted to the introduction, demonstration, and practice of the operational tasks which weapons mechanics routinely perform. These tasks are primarily gross psychomotor tasks, but they must be performed exactly in accordance with current technical orders (TOs) and usually in coordination with one or more team members.

The cognitive aspects of the course are not ignored - in reality they occupy an equal or higher priority for individual students. To a large extent this is because of the safety hazards and precautions which are inherent in the weapon mechanics job. Because of the nature of the tasks performed and the environment in which a large percentage of them are performed, it is extremely critical that students leaving this course not only master the "how" but also be extremely conscious of the "why" and "when" associated with each task they perform.

The course is made up of 11 blocks of instruction. The first three blocks are primarily academic in nature, and are taught by the lecture method; the remaining blocks provide procedural and "hands-on" training in two distinct areas:

1. weapons identification, structure and functioning, and
2. loading and troubleshooting of weapons and weapon systems.

The sequence, content, and time associated with each block of instruction are shown in the system flow diagram in Figure 7.

Review of the functions and tasks by block indicates that individualized mediated instruction could supplant presently used instructional methods according to the following schedule:

Block I - All

Block II - All

Block III - All

Block IV - 9-12 Hours

Block V - 6-9 Hours

Block VI - 10-14 Hours

Block VII - 24 Hours

Block VIII - 9-12 Hours

Block IX - 15-18 Hours

Block X - 24-28 Hours

Block XI - 18 Hours

This replacement ratio is based on the amount of time presently given over in these blocks to periods in which the instruction provided entails the learning of identifications, nomenclature, sequences, etc. For these portions of the weapons mechanic course, the substitution of individualized mediated instruction would provide the basis upon which individually paced hands-on training could be established.

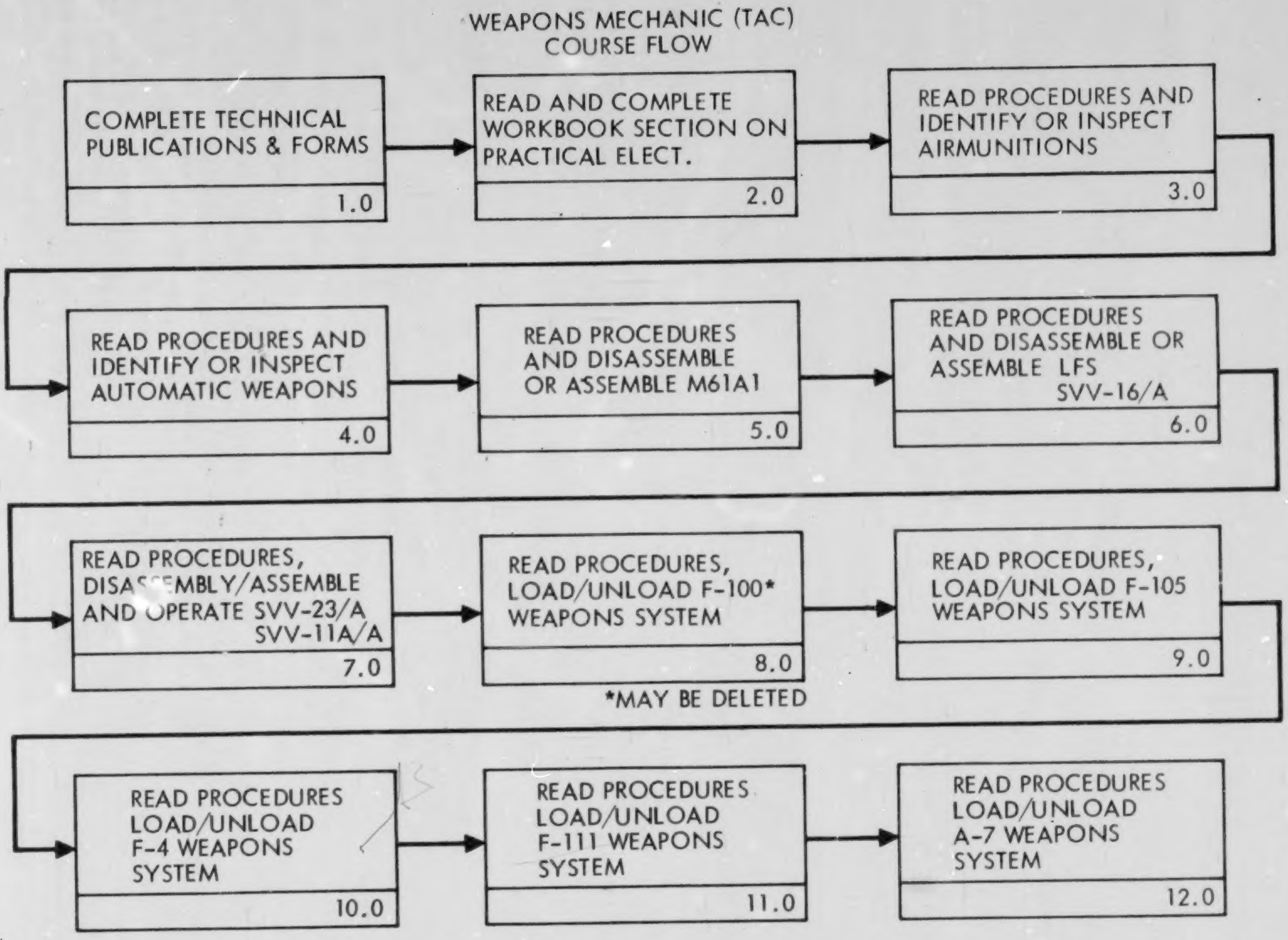

WEAPONS MECHANIC (TAC) COURSE FLOW
COMPLETE TECHNICAL PUBLICATIONS & FORMS
1.0
READ AND COMPLETE WORKBOOK SECTION ON PRACTICAL ELECT.
2.0
READ PROCEDURES AND IDENTIFY OR INSPECT AIRMUNITIONS
3.0
READ PROCEDURES AND IDENTIFY OR INSPECT AUTOMATIC WEAPONS
4.0
READ PROCEDURES AND DISASSEMBLE OR ASSEMBLE M61A1
5.0
READ PROCEDURES AND DISASSEMBLE OR ASSEMBLE LFS SVV-16/A
6.0
READ PROCEDURES, DISASSEMBLY/ASSEMBLE AND OPERATE SVV-23/A SVV-11A/A
7.0
READ PROCEDURES, LOAD/UNLOAD F-100* WEAPONS SYSTEM
8.0
*MAY BE DELETED
READ PROCEDURES, LOAD/UNLOAD F-105 WEAPONS SYSTEM
9.0
READ PROCEDURES LOAD/UNLOAD F-4 WEAPONS SYSTEM
10.0
READ PROCEDURES LOAD/UNLOAD F-111 WEAPONS SYSTEM
11.0
READ PROCEDURES LOAD/UNLOAD A-7 WEAPONS SYSTEM
12.0

Figure 7. Weapons Mechanic (TAC) Course **Flow**.

Specific media selections and rationale for each block of instruction in the weapons mechanic course are covered in this report.

Administrative and Physical Environments

In developing a system of instructional hardware to satisfy the functional requirements inherent to the baseline courses described in the previous section, some information is required about the milieu in which the system will operate. In developing the instructional carrel system described in this report, data of two types were found to be required by the project team. The first type of data required pertained to the actual physical locations, facilities, and existing systems with which the developmental system would be expected to interface. This included such factors as space constraints, available versus required power, and available versus required ventilation and temperature control. The second type of data was administrative in nature: number of students per class, number of shifts per day, number of hours for a given block instruction, etc.

The development of any type of training system is constrained to some extent by the environment in which training is to occur. Environment is defined here as including the physical and administrative factors which will have a bearing on the acceptance and utilization of an individualized, self-paced instructional system. While there are some other factors, such as instructor and student acceptance, which have a bearing on system success, the two classes of factors treated below are seen as having the most significant impact on the establishments of Air Force technical training.

The first of these factors, the physical environment, must in the case of the three baseline courses, be accepted as a constraint. Since the first version of AIS will be developed around the courses described in the preceding section, and these courses will continue to function within the existing physical facilities at Lowry Air Force Base, Colorado, those facilities represent a constraint on the design of the instructional environments deemed appropriate as a solution to the individualized instruction problem. A description of the constraints imposed by the presently available facilities is provided.

The second class of factors affecting the design of appropriate learning environments for individualized instruction are administrative in nature and includes such items as class size, duration, number of shifts per day, etc. Obviously, in this area AIS is going to cause some definite changes. However, it has been assumed that some of these administrative factors represent unchangeable aspects of the system and as such will function as constraints on carrel system design.

The extent to which instructional innovations, particularly those involving media, have been integrated into existing instructional systems in the past seems to confirm the belief that those innovations which impact least on the traditional role of the instructor have been accepted most readily.

In accordance with these and similar findings, we have identified those aspects of the baseline courses which would impact both the design and acceptance of instructional environments intended for individualized, self-paced instruction.

Physical Constraints

The initial implementation of a program for individualized technical training will be at Lowry and will encompass the three baseline courses described in the preceding sections. Each of these courses is under the control of a different department under the Technical Training Center. Each course occupies facilities which are physically separate from one another and which represent both different styles and eras of government architecture.

In each of these facilities there are two primary factors acting as constraints on the design of alternative instructional environments. These are:

1. The size of existing spaces within the structures allocated to each course and

2. The ventilation/air conditioning capacity of systems serving these spaces.

Space

In the development of instructional environments designed for individualized instruction, one of the primary constraints affecting the selection/design of the components are the dimensional limits imposed when trying to fit these designs into existing spaces. Most spaces in the existing structures at Lowry were designed to serve the instructional requirements inherent in the conventional forms of lecture or demonstration. As a result, they are sized on the basis of approximately 12.5 square feet per instructional position which is the accepted standard for classroom instruction.

In designing an environment intended for individualized, self-paced instruction, the minimum requirement for an instructional position, employing any media other than pure audio or text is 16 square feet. It is quite obvious that in order to accommodate 10 students in an environment specifically tailored for individualized instruction, a minimum of 35 additional square feet is required simply to house the students and additional presentation devices.

Ventilation/Air Conditioning

In addition to the constraint of available physical space, the ventilation/air conditioning characteristics associated with each of these spaces become a critical consideration in the selection of the equipment required for the presentation of certain types of instruction. If one considers that the heat generated by any electrical device is a function of its power consumption, then it is quite easy to visualize the problems inherent in the large scale utilization of mediated instructional devices designed for other uses. For instance, as a practical example let us take the case of a standard 35mm slide projector utilizing a 300 watt blub such as ELH. The output from that single projector is 1,194 Btu/Hr or roughly the equivalent of the thermal output of 2 men. (This figure is based on the following data: Energy output for personnel performing "light work" is 595-1190 Btu/Hr (Webb, 1964)).

As can be seen, the conversion of conventional classroom spaces to spaces designed to accommodate multiple individual stations using various media forms and equipment imposes an extremely heavy load on normal ventilating/air conditioning systems. Conversely, the capacity of existing ventilating/air conditioning systems acts as a constraint on the design of the mediated instructional system. Table 2 lists the capabilities of the ventilating and air conditioning systems in the representative spaces for each course.

Table 2. Ventilating/Air Conditioning Capacity

COURSE	BLDG. #	RM. #	CAPACITY	COMMENTS
PME	1433	108	82,000 BTU (Bldg. Unit)	INDIVIDUAL ROOM CONTROLS
IM	758	—	CONTINUOUS AIR FLOW (RATING = ?)	INDIVIDUAL ROOM CONTROLS
WEAPONS MECH.	813	—	PORTABLE FANS	
	1010 1499	—	CLIMATE CONTROL SYSTEM (CIRCULATION ONLY)	

Power

A third factor, but one which is more easily correctable in existing facilities, is the electrical distribution and supply system for a given instructional space. It is logical to assume that the power requirements for a mediated instructional system will certainly exceed the demand exercised by a conventional lecture/demonstration system. All of the representative spaces selected for AIS are serviced by one or more 115 V, 15 amp circuits. In addition to these circuits, the PME course has 60 amp circuits for their present work bench configurations.

While the 15 amp circuits would be adequate to service the installation of several projection devices, twelve, fourteen or sixteen carrels each drawing 5 amps, would require at least 4 circuits per room. In addition to providing the circuits to the room, attention needs to be given to the location and routing of service circuits to provide convenient and safe access for each carrel. There is the problem of providing unobtrusive and safe routing of power to instructional devices not placed in close proximity to existing walls. Reference to the alternative structural configurations described in this report will show that almost all alternative designs selected call for circulation of personnel and equipment on all sides of the grouped carrel structures. In order to permit safe and relatively unobtrusive provision of power to these designs, either under-floor or in-the-overhead routing of power cables would be required. At each carrel structure connection to service circuits would be via floor level sockets or a single power cord dropped from the ceiling to plugboards in each carrel.

The latter solution is more amenable for use in existing structures, since the former requires conduit or troughs under the flooring. The provision of electrical power to mediated instructional facilities and equipment in the hangar building used for weapons mechanic training represents quite a different problem than any of the other instructional environments. In the hangar the problem is mainly based on the sheer distances involved. The center of the hangar is as much as 200-300 feet from the sidewalls; the ceiling is 40 to 70 feet high and the floor consists of several feet of reinforced concrete.

Power can be supplied to instructional devices in the hangar environment, but only in one of the following ways: Alternative A would group all instructional devices along the sidewalls of the hangar; alternative B would run power lines to each instructional area (presently clustered at each aircraft) using metal ramp plates or sills to cover the lines as they traverse the floor; alternative C would replace the present "classrooms" in the hangar with 2 or 3 large trailers. These trailers could be placed in the same spaces occupied by the present TO library and "classrooms" and could be powered by multiple circuits originating in several feeder cables which would connect these new spaces and the existing services at the hangar sidewalls.

Alternative A is a distinct possibility and is desirable for its simplicity and low cost; however, since the amount of usable sidewall space is limited, and the distance from certain practice areas is quite long, its overall efficiency is questionable and should be empirically validated. Alternative B is possible, providing certain existing regulations and operating practices are changed. If, for example, the rules pertaining to "permanent" installations on the hangar floor cannot be revised then this approach with its attendent installation of instructional devices adjacent to the aircraft is not feasible. Alternative C is attrative as an approach, because it not only simplifies power distribution problems, but also because it allows solution of the ventilation and illumination problems for study in the hangar environment as well.

Lighting

Proper illumination is mandatory for optimum performance of visual tasks. Since knowledge acquisition and skill development in all three baseline courses are dependent upon the acquisition of information from visual sources, it is imperative that adequate lighting be provided. While the exact levels of illumination available in each representative space have not been measured, they are assumed to be about 70 footcandles at the work surface. Present illumination engineering standards indicate that this level (or a range from 50 to 75 footcandles measured with a calibrated photometer reading in footcandles from at least six points on the working surface) is acceptable for the tasks to be performed in the baseline courses. It is assumed that whatever design is selected for individual study positions, it will retain these levels of illumination at the work surface, either through a design which does not interfere with existing illumination or a design which provides adequate sources of supplemental illumination. In developing an instructional environment for AIS, illumination within the selected spaces must be designed to avoid shadows caused by carrel side panels, etc. Merely providing a uniform adequate illumination level at work surface height is not sufficient for spaces containing carrels, computer terminals and other forms of mediated instruction. The lighting layout and the design of spaces in which mediated instruction will occur require careful consideration to avoid problems of reflection and glare. In its initial implementation, the instructional environments described are existing facilities. Thus, any specific criteria with respect to light fixture characteristics, their placement and their relation to the instructional displays are not appropriate for consideration in this report. A few general considerations for the simplest instructional environment design are:

1. The student positions should be designed and laid out in such a fashion that the student is not consciously aware of the room lighting, either by direct sight or reflected glare.

2. Provision should be made for an even distribution of illumination across all displays and work surfaces at the individual study positions.

Noise

In the design of educational facilities, it is necessary to consider the levels of noise that will occur or be generated when the facilities become operational. The highest levels of noise generated by the instructional hardware, students at work, and ambient noise should not unnecessarily disturb the occupants of the facility nor impair their efficiency while at work. While it is impossible to specify precise noise level values that will be acceptable to all individuals, it is possible, and useful to identify the range of levels that are acceptable under average conditions.

In view of the basic premise underlying the design of facilities for individual instruction, it is mandatory that facility and equipment noise be controlled to levels that will permit necessary communication, information reception, and provide an environment sufficiently free from distractions to permit individuals to concentrate on the instructional materials and training tasks.

Over the years a number of criteria have been developed for specifying the acceptability of the acoustical environment in occupied spaces. These criteria are scales of subjective rating. They include levels of speech - interference, loudness, perception of noise, curves expressive of criteria as to noise and numerical ratings of noise. The "Noise Criteria" (NC) curves, developed by L. L. Beranek (Beranek, 1957), are a family of curves such that the "Speech Interference Level" (SIL) in decibels is the same as the NC number written on the curve. These criteria are more detailed than those concerned with loudness per se, or interference with speech. The criteria have been revised from time to time and are presently used in the form shown in Figure 8. The noise level for individualized instructional spaces should not exceed NC-40 and ideally should approximate the NC-30 curve in Figure 8. The introduction of mediated instructional equipment into these spaces shall not cause the noise level to exceed NC-40 as measured with a sound level meter meeting the design criteria specified in American Standards Association 24.3-1944 and 51.4-1961. Meter use should be in accordance with American National Standards Institute Standard ANS 51.2 "Method for Physical Measurement of Sound" with particular emphasis being given to B network measurements.

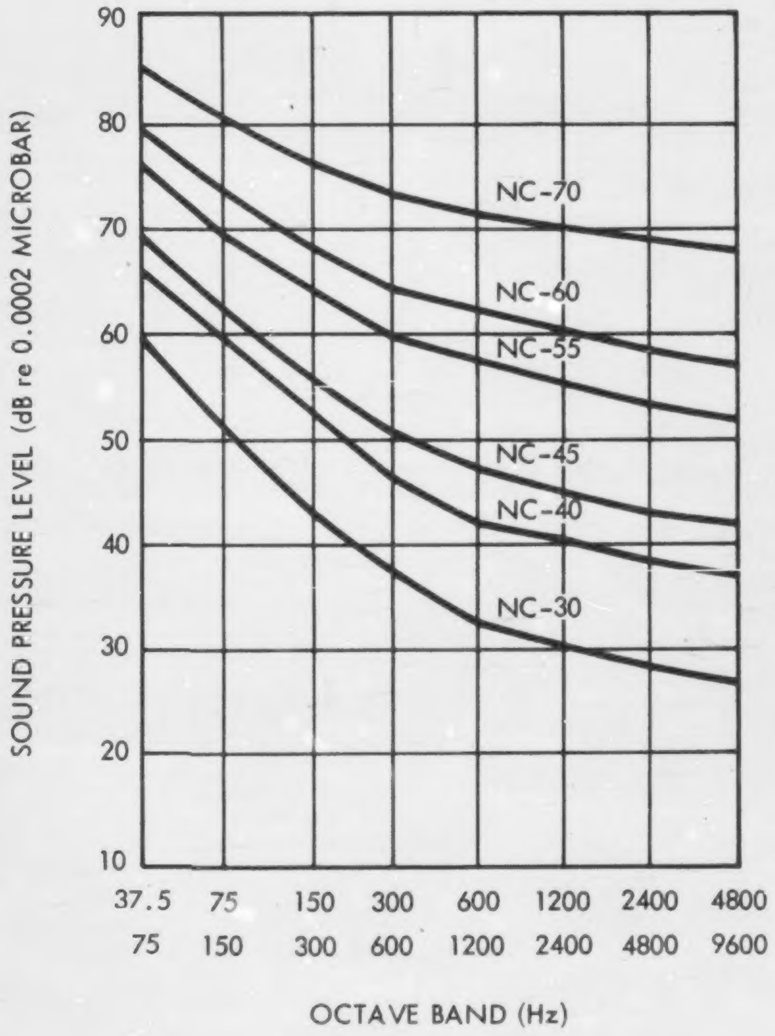


Figure 8. Noise criteria (NC) curves for speech communication. (Beranek, 1957)

III. INSTRUCTIONAL MEDIA

In accordance with the provisions of the statement of work for this study, a requirement existed to examine the state-of-the-art in instructional media and to evaluate the applicability of varied technological innovations, such as holography, computer animation, etc., to the instructional goals of AIS. In the systematic design of instruction, media selection represents a critical element in the iteration of the system. In the Westinghouse Study (1969), Rhode et al., stated with regard to media: "Viewed in the context of the model of the instructional process, ---, their critical role can be clearly seen, for the fact is that media have a strategic impact (in terms of constraints and freedoms) on this process. Different media, by their nature, impose different constraints on one or more attributes of the various (Instructional) model dimensions or, conversely, different media facilitate the implementation of various attributes."

Tosti and Ball (1969) take a somewhat different view in that they ascribe only disadvantages to any given medium; i.e., the selection of one medium over another only becomes critical when it places some limitation on the design of the instructional presentation. Saloman and Snow (1968) expand these generalizations by stating: "---one should expect interaction effects between particular media attributes, learner traits, and learning objectives, rather than main effects due to media attributes alone; in other words, a unique effect can be expected to result only when the use of unique medium attributes stimulates in the learner mental processes which are required for the production of a particular learning outcome."

The studies cited above represent a small part of the research which has been done with respect to the utility and effectiveness of instructional media. The dictionary definition of medium is the physical substance upon which something is recorded; that definition has been found to be too limited for use in communications and instruction.

For the purposes of this study an instructional or training medium is defined as the complete system of the equipment, processes, people, and materials that are necessary for the presentation of information and the direction of learner behavior. As Bretz (1969) has stated: "An instructional medium makes it unnecessary for an instructor to actually be present when and where a particular presentation is made. This kind of separation is possible because the instructional program contains all necessary parts of the message: Audio or visual stimuli and an exposition of some kind to give them the requisite significance."

A common feature to all media discussed is that they are forms and mechanisms whereby bodies of technical information are "fixed" temporarily in time. Instead of expecting to feed information into the real-time environment of live instruction and study, the function of media as an instructional form is to first "fix" the learning materials in both time and space: A given block of instruction becomes a physical object which can be manipulated, scheduled, stored and/or modified.

Having established an operational definition of media for this study, the question now arises as to which media should be selected for individualized technical training. The answer to this question must occur in two stages: The first stage representing the establishment of operational definitions for each medium to be considered and, the second stage, the explanation of the selection technique by which the characteristics of each medium are matched against the requirements of the baseline courses.

Visual media, in the sense intended here, are those media which convey instruction by means of sight. The student acquires the information contained in a given bit of data through his visual system. If this definition seems somewhat vague it is no more so than those presently existing in the field. Bretz (1969) identifies 5 classes containing 17 non-orthogonal media classes through which information is conveyed via the visual senses. Debons (1968) admits to a great deal of confusion with respect to exact definition of what constitutes a display system.

In the following paragraphs, our orientation has been to consider the recording or storage structure as the medium of information transfer. Thus, when we discuss the 35mm slide as a visual medium, we are discussing the information transmitting capability of an individual slide or group of slides rather than some more abstract concept of pictorial display.

In order to provide a semblance of structure and a series of identifiers for the classes of visual media we are dealing with, we have chosen to use a modified version of the taxonomic structure developed by Bretz (1969). Still visuals, as defined by Bretz include the still picture, the slide, the filmstrip, the microform and the printed page; and dynamic visual media represent a class presently composed of two distinct media - motion picture film, and video.

Still Transparencies

1. Format. The most common transparency format used for instructional applications today is the 2 inch by 2 inch or as it is commonly called, the 35mm slide. The most common format for 2 inch by 2 inch slides contain a 35mm double-frame (23 by 34mm) image. Figure 9 shows the relative size of the double frame slide image to the single frame (23 by 17.5mm) image of the 35mm filmstrip, and to four other image formats which are possible within a 2 inch by 2 inch mount. The double-frame 35mm slide is the most common format of transparency presently in use and has decided advantages with respect to availability of production and presentation equipment. While 3-1/4 by 4 inch and 2-3/4 by 2-3/4 inch slides have the capability for greater fidelity in rendition and coverage, their use continues to be limited.

2. Resolution. The resolving characteristics of commercially available 35mm films exceed the resolving power of the human eye with all but the most powerful projection systems. The information transmission capacity of visual imagery far exceeds the information extraction capability of the eye as well. To maximize the effectiveness of the still visual imagery in individualized instruction requires the clear display of a single concept in a given image, thus, the composition of a given slide image is the real limiting factor determining the utility of this form of visual presentation.

Filmstrip

Just as the name implies, the filmstrip is a strip of film. It is an organized sequence of images designed to present a specific message. The major advantages of the use of filmstrips lie in their lower per frame cost and the diversity of the equipment available to present materials prepared as filmstrips. At the present time the most common filmstrip format consists of a series of 35mm single frame images ordered vertically on a single piece of film stock (see Figure 9). However, there is an increasing use of 16mm and Super -8mm filmstrip systems. The specific technical characteristics of these formats are described below:

1. 35mm. The 35mm filmstrip format employs a frame size of 17.5mm by 23mm with the larger dimension in the horizontal plane (see Figure 9). This format is identical in dimension and orientation to a frame of 35mm movie film; it differs from 35mm slide frames in overall size, orientation (see Figure 9), and in the proportions of the image area (2:3 vs 3:4). Since the same film stock is used for both formats, resolution and exposure characteristics are similar.

In comparison to a 35mm slide set, the required storage volume for filmstrips is minor (see Table 3). When one considers that each of the 16 students in inventory management, for example, would require a tray of slides per hour of instruction recommended for mediation, then the impact of storage requirements as a characteristic of media becomes quite critical. Assuming that we have only 16 students, then one hour of instruction would require that we have a storage capacity for 16 presentations, plus 20% for spares = 20 slide trays or 20 filmstrips. Thus, a single hour of instruction would require a storage area accommodating 4400 cubic inches of slide trays alone (not including the storage required for accompanying audio materials) versus 70 cubic inches for 35mm filmstrips.

Projection devices for filmstrips intended for audio-visual applications are functionally similar to the equivalent categories of slide projector. The major difference is of course, that single frame filmstrips are transported vertically with images descending into the aperture of the projector; this uni-directional vertical movement plus the short distance to be traversed allows filmstrips to change images quickly enough to give the impression of animation or successive still frames in a movie.

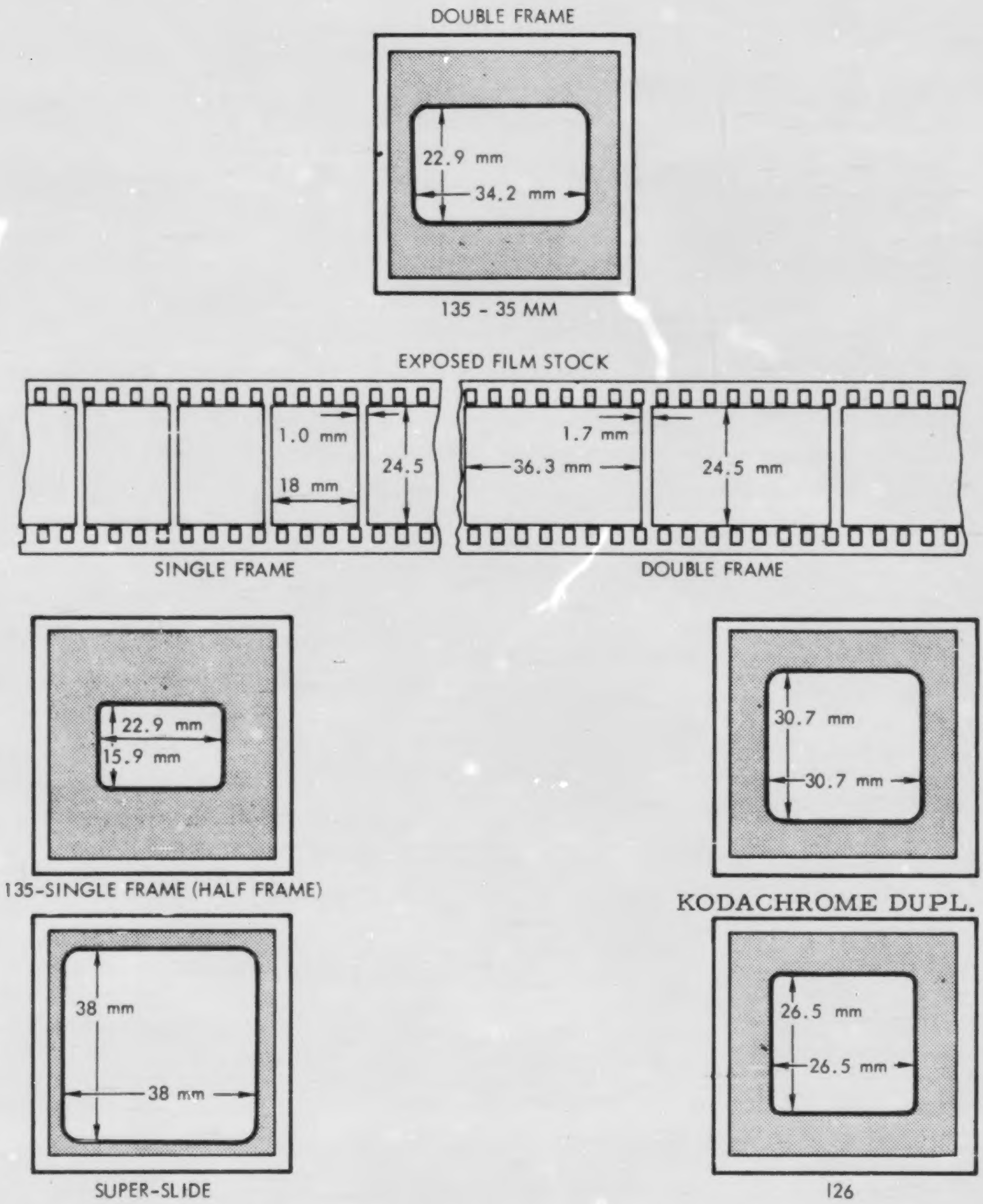

DOUBLE FRAME
22.9 mm
34.2 mm
135 - 35 MM
EXPOSED FILM STOCK
1.0 mm
18 mm
24.5
1.7 mm
36.3 mm
24.5 mm
SINGLE FRAME
DOUBLE FRAME
22.9 mm
15.9 mm
135-SINGLE FRAME (HALF FRAME)
30.7 mm
30.7 mm
KODACHROME DUPL.
38 mm
38 mm
SUPER-SLIDE
26.5 mm
26.5 mm
126

Figure 9. 2 inch slide formats.

In addition to conventional projection devices for 35mm filmstrips, a host of stand-alone projection systems have been developed for this format. These devices are particularly appropriate for individual study, are simple to operate, relatively low in cost and provide a degree of scheduling and assignment flexibility not possible with any other still visual format. In their simplest form these devices are hand operated viewers operating on penlight batteries. In their most sophisticated form they are true audio-visual systems containing a projection system synched to an audio cassette system and its own rear projection screen. As a means of home study, remedial, or supplemental instruction, these devices certainly enhance the overall attractiveness of the 35mm filmstrip as an instructional media.

2. 16mm. The 16mm filmstrip format employs standard 16mm movie film. It is a length of film containing 350 to 440 frames which can be advanced singly or at rates up to 10 changes per second. The major advantages of 16mm filmstrips are the low cost of raw filmstock, the wide range of film types available, and the high storage density theoretically available. The disadvantages associated with the format are the limited availability of projection devices and systems, the requirement for special cartridges to hold the film, and the high cost and sensitivity of 16mm filmstrip origination equipment (standard 16mm movie cameras are expensive devices; modifications which allow single frame exposures are even more expensive).

Resolution and image quality of 16mm original footage and duplicates are equal to that which the human eye can discern on 35mm. The entertainment film industry has maintained as its industry standard 35mm film. However, with increasing frequency 16mm footage is being used as original footage and optically blown-up for incorporation into or distribution as 35mm footage. The criteria and standards established for these applications are far more severe than what is expected of instructional filmstrips.

The technical characteristics of 16mm film, plus its low cost as a volume production item make it an extremely attractive audio-visual tool. However, the small number of projection and handling systems on the market limits both the availability and application of this format.

Both of the available 16mm filmstrip systems use a separate audio tape (integrated into the film cartridge) as the source of sound to amplify or supplement their visual presentations. Synchronization of imagery and audio is attained by using cue commands on the tape.

3. Super 8mm. The Super 8mm film format retains the proportions of 16mm and 35mm (single frame) film. First introduced in 1965 as an "amateur" or home movie film format to replace the then standard 8mm film, Super 8 has made impressive gains in the amateur market and has begun to gain acceptance as a low cost reduction/release format for 16 and 35mm originals. Its use as a filmstrip format has been limited to one relatively successful and several extinct systems.

	35 mm Slide	3M Sound-On-Slide	35 mm Filmstrip	16 mm Filmstrip	Super - 8 mm Filmstrip (RCS)	Super - 8 mm Filmstrip (PIP)
"Typical" Package Volume	220 Cubic Inches	160 Cubic Inches	3.5 Cubic Inches	37 or 45 [1] Cubic Inches (Including Sound Track)	11.78 Cubic Inches (Including Sound Track)	9.43 Cubic Inches
Per Frame Volume	2.75 Cubic 2.20 Inches 1.57 (Depending on number of slides in tray.)	4.44 Cubic Inches (Including Sound Track)	.04 Cubic Inches for a 72 Frame Filmstrip	.37 Cubic Inches per frame for a three foot long (120 frame) strip.		

Compact
Cassette (Audio) Volume = 8.77 Cubic Inches

① There are two cartridge sizes available.

Table 3. Storage Requirements for Filmstrips vs Slides

The use of Super 8mm as a filmstrip format is predicated on the same factors that make 16mm an attractive filmstrip format: low raw stock cost, satisfactory image quality, low duplication costs and reduced storage density.

Its drawbacks are: the limited availability of presentation systems, the lack of standardization between systems, and the relative difficulty of original footage generation. The limited availability and lack of standardization between presentation systems are all too characteristic of the audio-visual field. While from a business standpoint it is enviable to obtain and successfully market a unique product, the user's view must be somewhat less optimistic since all too often the disuse of the unique product leaves the user with an investment in equipment and software that has no future.

The optical quality of Super 8mm as a filmstrip medium is sufficient to satisfy the requirements of individual presentations. The cost of raw film stock is lower than that for 16mm and camera equipment is available. The problem with expanded Super 8 filmstrip utilization lies with two sources: the processing and editing of original footage and the refinement and standardization of presentation and display systems.

Still Pictures

The still picture (here defined as the pictorial representation of an object produced via photographic means), whether a print or a projected transparency, has the capability to convey a large percentage of the types of information available in the instructional setting.

General Characteristics

As can be seen in Table 4, the types of information that can be conveyed, the types of learning that can be supported, and the transmission characteristics of the still picture make it extremely attractive as a means of presentation. Table 4 is keyed to color photography, however, the characteristics of black and white photography would be similar.

Combined with these characteristics is the relative ease with which acceptable instructional material can be generated and the low costs associated with still picture production. This leads to the conclusion that the still picture is a superior means of conveying information in the technical training environment.

Content Characteristics

The content characteristics of the still picture used for instructional purposes, must remain the responsibility of instructional materials specialist. Only he knows what it is he wishes to convey. The dimensions, reproduction techniques and presentation techniques used for photographic prints are somewhat flexible. Two types of pictorial transparencies dominate the instructional market: the slide and the filmstrip.

INFORMATION TYPE

	SYMBOLS					SIGNS					
	WRITTEN	COLOR	GESTURAL	AURAL	TACTUAL KINESTHETIC	PICTORIAL	DYNAMIC PICTORIAL	COLOR	GESTURAL	AURAL	TACTUAL KINESTHETIC
PHOTO PRINTS	YES	YES	LIMITED	NO	NO	YES	LIMITED	YES	LIMITED	NO	NO
SLIDES	YES	YES	LIMITED	NO	NO	YES	LIMITED	YES	LIMITED	NO	NO
FILM STRIP	YES	YES	LIMITED	NO	NO	YES	LIMITED	YES	LIMITED	NO	NO

ATTRIBUTES

	DISPLAYS MOTION	SPEEDS UP OR SLOWS DOWN	MAGNIFIES OR REDUCES	FIXED OR VARIABLE SEQUENCES	FIDELITY OF DISPLAY	CUE SUMMATION	FEEDBACK POSSIBLE	EASE OF OPERATION	3-D CAPABILITY	
PHOTO PRINTS	LOW	N/A	HIGH	VARIABLE	HIGH	NO	VARIABLE	HIGH	N/A	
SLIDES	LOW	N/A	HIGH	VARIABLE	HIGH	NO	NOT TYPICAL	HIGH	N/A	
FILMSTRIP	LOW	N/A	HIGH	FIXED	HIGH	NO	NOT TYPICAL	HIGH	N/A	

PRODUCIBILITY

	ORIGINALS GENERATED LOCALLY	PROCESSING POSSIBLE LOCALLY	DUPLICATION POSSIBLE LOCALLY
PHOTO	YES	YES	YES
SLIDES	YES	YES	YES
FILMSTRIP	YES	YES	YES

Table 4. Still Picture Characteristics

Effectively, a set of slides and a filmstrip are identical with respect to their information transmission characteristics. However, there are three factors which differentiate them.

1. Instructional Materials Development. Are we developing and revising prototype materials, or are we dealing with the production of ready-for-distribution materials? Does the material we are dealing with require very frequent, small changes in content? A positive answer to these questions would lead to the selection of the slide set as the most efficient method of presentation for a given application. Filmstrips lend themselves best to applications in which the continuity is established or for mass distribution of a message to be presented once.

The production of slide sets and filmstrips differ only with respect to the image formats and the finishing procedures employed. The procedures for production and even processing can be almost identical for both formats. With the proper equipment it is entirely possible to ignore the end use packing concept during production.

2. Quantity. Depending on the other factors listed here, the number of copies required of a given instructional presentation is usually the determining factor as to whether one adopts slides or filmstrips as his presentation media. If only a single copy, or up to five copies, is required, then slides offer significant advantages in terms of cost, availability and ease of acquisition. For copies of presentations which exceed six in number, the cost advantages of filmstrips in multiple copies plus their lower storage and distribution costs certainly merit consideration (Trow and Smith, 1965). Once the required number of copies exceeds 10, there is little doubt that filmstrips represent the most efficient and cost-effective means of presentation.

3. Production Equipment. What is the availability of appropriate production equipment? The production of slides, even in quantity, is a relatively simple procedure - it requires only relatively inexpensive and readily obtainable photo equipment and the services of any competent processing laboratory. Even moderate volumes of filmstrip production require the use of special equipment outside the realm of most small operations. Thus, only with a serious long range commitment to filmstrip production is it efficient to consider their production locally. Under other circumstances, filmstrips can be obtained by providing all required flatwork or transparencies to a commercial filmstrip producer.

Motion Pictures

The effectiveness of the motion picture as an instructional medium was established prior to 1940. Many research studies were performed during and immediately following the second World War. This research (summarized in Hoban and Van Ormer, 1951 and in Hovland et al., 1949) still represents a largely unexploited reservoir of information. The previously cited references, plus the research summaries prepared by Allen (1959) and Lumsdaine and May (1965), provide extremely comprehensive and detailed information with respect to the utility and application of instructional films. The particular aspects of the research on motion pictures that bear on the design of individualized technical training are summarized. Motion pictures are an effective means for communicating factual information. Motion pictures are an effective means for training motor skills, particularly when used in combination with other teaching techniques and media. There is some evidence that films can develop conceptual information successfully and effectively.

The specific production techniques having the greatest impact on human performance are covered most comprehensively in Hoban and Van Ormer (1951). What distinguishes the use of films in general from films intended for individualized instruction is not so much the production techniques employed to develop them, as it is the intent of the presentation and the logistical aspects of its employment. For individualized technical training, the single concept film represents the only efficient use of this medium. The logistical aspects of using motion picture films for individual instruction are covered below in our discussion of each film format. There are at the present time only two motion picture film formats that are considered relevant to instructional purposes. These are the 16mm and Super 8mm formats. While numerous other motion picture formats exist, their domain is almost exclusively the large screen, commercial motion picture market. Rarely, if ever, are the equipment and production skills associated with these formats applied to instructional film development.

16mm Format

The 16mm motion picture format has an image size of 12 by 9mm and is exactly one half the size of 35mm motion picture film. The 16mm format was developed some fifty years ago as a lower cost or even "amateur" alternative to 35mm film. Its acceptance as a "professional" medium, particularly in the entertainment field, is still being sought. As the development and distribution medium for instructional films, it has reigned unchallenged since the second world war. As a documentary, recording and audio-visual presentation medium, it is still the tool to be used. Its successful history as the format for military, industrial and other non-entertainment motion picture applications has led to a proliferation of equipment, films and processing systems which are tailored to the specific characteristics and requirements of this format.

The long and continuing developmental history and the availability of precisely engineered camera, film, and processing systems make the 16mm format technically very attractive as the motion picture production and distribution medium for instructional purposes. The fact that until recently there have been no competitive systems of equivalent technical quality or cost has, of course, helped to maintain the primacy of 16mm. There are, however, several major drawbacks associated with the use of this format, both as a production and as a distribution medium. In the following paragraphs, certain of these advantages and disadvantages and their implications for a program of individualized training are discussed.

1. Cost. The costs associated with the use of 16mm film as a generation and duplication medium are diverse and varied. The cost of a given piece of 16mm footage is highly dependent on what is being recorded on the film, when and how. Quite obviously, the cost of simply recording an instructor's demonstration is considerably less than recording the same activities on a flight line somewhere. Similarly, a straight recording sequence will be cheaper than one in which special graphics, titles or animation is required. The specific breakdown of costs associated with 16mm motion picture production are covered in this report. For our purposes the often quoted figure of $1,000 per minute (production cost) for a completed master copy still seems to be a valid metric against which one can equate one's requirements. (It should be noted that these costs vary not only as a function of material photographed, but also as a function of whether one is pricing the development of a new capability, purchasing completed packages, or expanding and capitalizing on existing capabilities.)

2. Production. The production, both initial and final, of quality 16mm film presentations is a complex and precise undertaking. For reasons which are almost a direct function of the costs involved, 16mm film productions are relatively large scale undertakings, requiring the services of personnel trained in the rather precise arts and sciences of script development, cinematography (motion picture photography), large volume film processing and the post-production tasks associated with finished film generation. From a production standpoint, the availability of a varied spectrum of equipment, accessories and film stocks allows the production of 16mm footage under conditions that are impossible in almost any other format.

3. Presentation. The image area of 16mm film dictates the number of frames that can occupy a given space (40 frames to the foot). Similarly, the speed at which images are projected dictates the amount of footage that is required to present a message of given duration. 16mm motion picture film is typically projected at 24 frames per second (fps); thus, even for relative short sequence, 16mm films require a significant amount of footage. Presentation of 16mm films is at present limited to relatively standardized, vertically oriented projection systems of considerable size and bulk. With one or two exceptions, the available projectors are neither designed nor intended for stand-alone or study carrel use. Even the exceptions are primarily standard projectors fitted with right-angle projection optics and rear-screen projection enclosures more suited for display or advertising purposes than for student use.

The display of 16mm presentations via television is a standard, well developed procedure. In most applications it is done for one or more of the following reasons:

1. The 16mm footage is required to be viewed simultaneously by several groups in different locations.

2. There already exists a CCTV system servicing the various locations.

3. The footage represents instructional material which is frequently repeated (e.g. every week), thus, 16mm film represents a cost effective storage medium.

4. The material is used so infrequently that it does not warrant the production of additional copies.

5. The 16mm footage is a stable and cost effective long lived storage medium for material generated originally as videotape.

Super 8mm Format

Just as 16mm film represented an attempt to retain the motion picture medium while reducing the size and complexity of the film and equipment required by 35mm, so 8mm (standard 8) was an attempt to divide 16mm film in half and produce similar results with equivalent savings in size, complexity and cost. First introduced in 1932, standard 8mm film was in fact 16mm film exposed on one half of the film at a time. During processing the film was slit down the middle and shown as 8mm film. Originally intended for the amateur market, standard 8mm remained primarily an amateur filmmaker's toy, the source of innumerable jokes about "home-movies". In 1965, Eastman Kodak introduced Super 8mm film as a replacement for standard 8mm film. While the dimensions of film stocks are the same for both formats, Super 8mm provides a 35 per cent greater image area per frame than standard 8.

Since its introduction in 1965, Super 8mm has virtually eliminated standard 8 from the amateur market and has made significant in-roads in an area that was hardly touched by standard 8mm audio-visual and instructional applications. One of the advantages of Super 8 is that the image area/aspect ratio allows images to be reduced from 16 or 35mm without any image loss. It has become quite attractive as an inexpensive release and distribution medium. Super 8's popularity and technical quality has produced a continuing series of developments and refinements in equipment and materials for its origination, production, processing and distribution. Significantly, these developments and refinements have been made by some of the major firms in the photographic and audio-visual industries, indicating both a long-term and conscious commitment to the development of Super 8 as both a production and distribution medium.

Significant aspects of this development and refinement process having a bearing on individualized training are the continuing emphasis on the use of magnetic sound for Super 8, the development of several competitive packaging concepts for Super 8 distribution, and the development and/or modification of quality equipment for Super 8 photography, processing, editing and volume duplication. Of particular note is the commitment of

Eastman Kodak to the concept of Super 8 as an "audio-visual system" and their associated development of more professionally-oriented film stock (allowing higher quality duplication from Super 8 originals) and display/projection equipment designed specifically for Super 8 w/magnetic sound, including a Super 8mm based video player system (a compact film chain for playing Super 8mm film over a regular TV receiver). For our purposes, the Super 8mm motion picture format has the following distinct advantages over 16mm and video.

1. Cost. The cost of Super 8mm raw stock, camera equipment and accessories required for the production of film sequences for instructional purposes are significantly less than that required for 16mm motion picture work. The mean production cost for Super 8mm is cheaper than the same sequence done as 16mm. This cost advantage permits the development of Super 8mm presentations which, because of their low cost, could be disposed of or replaced when the technical content of an instructional segment changed.

The second thing that becomes possible with the adoption of Super 8 is the allowing of instructional personnel to generate their own instructional film sequences, either in preparation for more polished development by a film unit or to fill a gap left by budgetary, schedule or changed program requirements.

2. Production. The equipment required for the production, duplication, and finishing of Super 8mm film productions can be as complex and sophisticated as that required for 16mm motion picture work or it can be done with equipment costing under $500 for a complete facility. The quality of the output would vary over a wide spectrum, but not necessarily in direct proportion to cost. At the present time, camera equipment for Super 8mm work is available which will produce results equivalent to anything available for 16mm work. The problems that are present in Super 8mm production work are primarily associated with the available filmstock and the processing and editing of Super 8mm film.

3. Presentation. The success of Super 8's acceptance by the amateur, audio-visual, and instructional community has led to a proliferation of manufacturers' models and techniques for presenting Super 8mm films. The audio-visual directory (NAVA, 1972) lists 19 manufacturers for Super 8mm presentation devices encompassing 40 models of which 13 are stand-alone systems. In order to select presentation equipment suitable for instructional purposes, one must first decide if an integral sound track is required (this would limit the available spectrum to 27 models), and then select the packaging concept one wishes to adopt (a choice of at least 6 different types of which only 2 are compatible).

4. Packaging. There are two basic approaches to packaging Super 8 film; cartridge systems and reel film. Film reels contain from 50 to 800 feet of Super 8 film. It is a very straight-forward approach to film storage and display, however one which is not altogether satisfactory in an individual training environment where each student would be expected to load, thread and operate the projector.

Available cartridge systems are of two basic types: endless loop systems and self-threading cassette systems. Of the two, the endless loop system is the older form having been introduced in 1961 by Fairchild for regular 8mm film. At the present time only 3 major endless loop systems are available on the market, these are the Technicolor, Fairchild, and A. B. Dick systems. While continuous-loop cartridges have certain advantages with respect to simplicity of operation, they are definitely handicapped by the lack of a standardized cartridge, and their inability to fast forward or reverse and stop-frame operation is often of marginal quality.

Self-threading cassette systems for Super 8mm film are essentially two-part systems; a packaging module which acts as the storage container for a given piece of footage and the handling module, integral with the projector itself, which automatically positions the film during the threading projection and rewinding. At the present time there are two major self-threading cassette concepts available; the European developed E. P. (Ease Play) cassette system and the Eastman-Kodak (EK) Cassette. In concept these systems are identical - the Super 8mm film is taken as it returns from the laboratory and simply placed, spool and all, into a container which will act as both a storage container and as an integral part of the projection system. In use they are also identical, the cassette is simply placed into or on the projector and the projector automatically threads itself and begins the play. It is only in the detailed implementation of these concepts and the capabilities of available projection devices that the E. P. and EK systems differ.

While the E. P. system was developed by a consortium of several European firms, apparently only one firm, Bolex, markets projectors for the E. P. system and these are limited to the projection of 50 foot (3-1/2 minutes) cartridges. The EK cartridge system consists of four cassettes (50, 100, 200 and 400 foot capacity). Eastman, and at least two other manufacturers of projection equipment, have redesigned their Super 8mm product line around the EK cassette system.

The major advantage to the cassette system is that, depending on the sophistication of the projection equipment selected, the cassette can be stop-framed, reversed, fast forwarded or set to play a given sequence repeatedly.

Continuous loop cartridges require special loading equipment and splicing prior to actual loading. Cassette production on the other hand is only slightly more complex than loading the film into a storage box. In both forms, cartridge and cassette, some type of film lubricant needs to be used.

Summary

In summary, it can be stated that the cost, production requirement, and lack of suitable display systems would seem to limit the utility of the 16mm motion picture format as a medium for inclusion in an instructional environment intended for individually paced, mediated instruction.

The preceding discussion of Super 8mm film as an instructional medium has assumed an integral sound track synchronized to the visual presentation. At the present time, the sound track technique for Super 8mm film is a magnetic stripe printed onto the base side of the film. Optical sound as a part of the Super 8mm system has proved infeasible because of the inability of any of the elements of the recording, printing, and playback systems available for Super 8 to adhere to the required tolerances (2.5 mils) for any extended period of time.

For the instructional environment designed to support individualized technical training, Super 8mm motion picture with magnetic sound in appropriate cassettes or cartridges are recommended.

Microforms

A different medium for storing and displaying still-visuals that has been employed with limited success as an instructional medium is microforms. A generic term denoting any of several products of the microphotographic process, microform is essentially a synonym for microimage and includes both microfiche and microfilm. Microforms are basically sheets of film carrying rows and columns of microimages which through the use of suitable projection systems, can be made visible to the human eye. To date the primary application of microforms has been as a high density storage medium for large masses of data. Under the auspices of the Air Force, however, certain innovative instructional applications for microform have been developed and demonstrated experimentally (Frick, 1970; Grausnick, 1971). These studies have shown that microforms have definite instructional application, but that the logistical and presentation hardware problems associated with the large scale application of microforms for day-to-day instruction will delay its wholesale application.

Microimage is defined as the filmed image of the original document reduced in size to a point where it cannot be read by the unaided human eye. Magnitude of reduction depends on the size-detail, and contrast of the material printed on the original documents and the legibility required of the microimage. The size of microimages is commonly expressed as the ratio between the original document and the copy or the reduction ratio. Thus, if a reduction ratio is 24:1 or 18:1, then a document measuring 24 inches or 18 inches (see Reduction Ratio) respectively occupies 1 inch of film in length. At 18:1 an 8-1/2 x 11 page would occupy an area 7/16 by 5/8 of an inch.

Classes of Microform

Microfiche. Derived from the French, microfiche has come to describe a transparent sheet of film containing microimages. There are several types and several sizes of microfiche in existence today.

1. Unitized Microfiche. The unitized microfiche uses 105mm film in a step-and-repeat camera capturing images in a precise grid pattern.

2. Microfiche Jackets. This form of microfiche uses 16mm film to record the document on a frame-per-page basis. The film is cut into strips of 10 or 12 frames and inserted into acetate jackets. These jackets are then used as masters and copied for distribution, or are distributed directly to the user.

3. Microtape Systems. This approach applies a special adhesive to the microfilm after it has been developed. The microfilm is then cut into strips and laid upon a sheet of acetate in the proper order. This sheet of acetate is thus a master from which copies may be made and distributed.

4. 105mm x 148mm (4 x 6 inches). This size of microfiche is recognized as the standard size by the U. S. Committee of Scientific and Technical Information (COSATI) and is standard size for all U. S. government agency microfiche. This standard was adopted by the U. S. government in 1964-65 and is one of the standard sizes recognized by the National Microfilm Association (NMA).

The format for the 4 x 6 inch fiche consists of two fundamental parts: the heading and the images. The heading contains a description of the document and may contain any or all of the following information: title, author, publisher, classification, identifying numbers, number of pages in the document, and number of fiche containing the document. This information is located at the top of the card and is readable with the naked eye. A 4 x 6 fiche normally contains 60 images arranged in five rows of 12 images each. On the first fiche for any document, 1 row is lost to the header; on each succeeding fiche approximately 3 image spaces are lost to identification data readable with the naked eye. The individual pages are normally in sequence reading from left to right. (The COSATI standard was recently changed from this 18:1 reduction ratio to 24:1.)

5. 3 1/4 x 7 1/2 inches. The tab or standard EAM card size microfiche or aperture card (so-called because the microimage appears in a cut-out or aperture in the card) is recognized as a standard size by the NMA and has found a high degree of acceptance in the storage of large size single sheet documents such as maps, charts and engineering drawings and some automatic/mechanical retrieval systems in which superior handling is possible with the tab-card format as opposed to 4 x 6 inch size.

The major advantage of the 3 1/4 x 7 1/2 format is that it is retrieved or handled using conventional punch card equipment (modified to prevent contact brushes from damaging the film). While the aperture card represents a substantial improvement over manual techniques for handling outsize documents, its utility as a medium for handling report type documentation is limited by the restricted film area available on a per-card basis. Standard aperture cards contain a 35mm film frame 1 3/8 x 1 7/8 inches in size. The number of pages that can be accommodated in this area is restrictive if standard recording densities are adhered to. The desirability of the tab card format in terms of its use with particular systems will be considered with the discussion of particular systems in this report.

6. 3 x 5 inch. The 3 x 5 inch (standard library card) format was used in many early microfiche applications. Using the same image size as the 4 x 6 size, it will hold approximately 40 to 50 pages. The major advantage of this size fiche is that it can be stored in standard catalog card files.

7. Full Page Fiche. Efforts have been made to utilize an 8 x 10 inch fiche, or equivalent in one of two ways. First, the full-page fiche would be used so as to store very large collections of information at ultrafiche reduction ratios. Secondly, the full-page fiche concept allows for indexing individual images, putting normal-reading images (indexes, keywords, etc.) on the lower half of the fiche, while the corresponding image in reduced form is visible on a reader. NCR and others have attempted to develop effective systems. It is doubtful that the full-page fiche will be an effective medium until readers are developed that are about book size, thus allowing reading of book size fiche in a book-sized container (SDC, 1970).

8. Ultrafiche. This fiche format is distinctive not for the size of the individual fiche (commonly 4 x 6 or 5 x 8) but rather the recording density used. While conventional fiche contain approximately 60 images, ultrafiche (by using reduction ratios in the 90 to 210:1 range) have a capacity of approximately 2,000 pages per fiche. This high-reduction range has not proven to be attractive to the document retrieval field. Improvements in equipment, price and fiche-indexing may allow competitive utilization of high density microfiche with cartridge film and magnetic memory devices.

9. Formats. Reading tests seemingly indicate that vertical reading for microfiche is more effective than horizontal reading. Thus, if the images were arranged so that pages were read vertically along the 6-inch dimension, there would be 5 rows of 12 images, scanned vertically. Atlantic microfilm has proposed the vertical fiche, in which there would be 12 rows of 5 images each, suitable for computer printout. Suggestions have also been made regarding employment of alternate reading sequences (e.g., boustrophedon, spiral). However, to date, no publications have

announced using such formats. Present capabilities for handling oversize pages in microfiche require turning the image sideways. COSATI specs provide for normal reading layout only. Many COSATI fiche are produced with the side-reading pages.

Microfilm. Roll microfilm is commonly available in two sizes: 16mm and 35mm. While 70mm and 105mm film are used for microfilm purposes, they are used for special purposes: 70mm for aperture cards and 105mm for COM or shooting fiche masters. While 35mm film is still used, 16mm ready-to-use film is the most common form of roll microfilm. Ready-for-use roll microfilms are spooled into three basic types of containers.

1. Reel. The reel is a flanged holder that holds up to 100 feet of film. Reels should be stored in separate cardboard containers for film protection and identification. When used on most viewers, the reel is threaded manually which is often troublesome. Reel microfilm can be converted to either the cassette or cartridge container at a small additional cost.

2. Cartridge. The cartridge (sometimes called a magazine) is an enclosed single-core container that eliminates many film handling problems associated with reels. The film (normally 100 feet) is totally enclosed with attached leaders and is self-threading when used in most motorized cartridge viewers. Information look-up is accomplished with the aid of a resettable odometer that is available on many readers. Cartridges for microfilm have not been standardized in design and, as such, are not interchangeable in many cases.

3. Cassette. The cassette (sometimes called a cartridge) has many of the same characteristics as the cartridge. Its design differs in that it contains a double core which provides both film supply and take-up. This feature allows the user to remove the cassette (without rewinding) for referencing the same frame at a later time.

Microcard. (Microcard is a trademark of NCR, Incorporated, Dayton, Ohio.) Microcards are positive opaque photographic prints 3 x 5 inches in size. Normally 40-letter size (8 1/2 x 11) pages appear on each side of a microcard. Its major market as a medium is for a limited set of users having a requirement for frequently revised, detailed material (i.e., tech orders, spares manuals, etc.).

Film Stock (Material in this section excerpted from RADC, 1967.)

Widely available microfilm stocks are of three basically different kinds. The first (and most commonly used) is made up of two elements: an acetate base and a photosensitive layer of silver halide called the emulsion, which is bonded to the base. This is identical in construction to the film used in everyday amateur photography but with higher gamma characteristics. The second, also widely used, is diazo film stock.

Diazo differs from silver halide film in several important respects, and these differences give diazo very useful properties for certain applications in document storage and retrieval. The third type is called kalvar, and is entirely different in concept from either diazo or silver halide film.

1. Silver Halide. Silver halide film is generally preferable for archival storage and recording purposes because it retains its image much better with time. Since the image is actually recorded on the emulsion, however, it is much more susceptible to tearing, scratching, pinholing, and other physical defects, and therefore must be handled as little as possible. Master record copies of documents should be made on silver halide film, but duplicate negatives must be made for use in a working file.

2. Diazo Film. Diazo film is a slow film and takes longer expose than silver halide. Development, however, is a rapid-dry process that can take place in a lighted room. Because of the speed of development, the overall duplication cycle for diazo is significantly faster than for silver halide. The emulsion of diazo is incorporated into the base material. Because of this, the diazo image is much less susceptible to damage during handling by machines. After a period of time, however, the diazo image tends to fade. This property makes it unwise to use diazo for archival purposes. However, because of the resistance of the image to physical damage during handling, diazo is better suited for use as a working file copy from which blowbacks or frequent duplicates are made.

Diazo has the property of reversal development. This means that it makes a negative image when contact-printed from another negative. In creating a duplicate silver halide negative, however, an intermediate paper positive must be made. This means that the duplicate silver halide negative is actually a third-generation film, while the duplicate diazo negative is second-generation. Each additional generation step incurs a loss of detail quality.

In summary, the properties of diazo film are ideally suited to its use in a working file where it may receive considerable handling. On the other hand, the property of long image retention makes silver halide film best suited for archival master copy storage. As a master copy it need be handled only when a new diazo working copy is needed. Concerning costs, the two film materials are approximately equal in cost, but diazo is cheaper to process in small quantities.

3. Kalvar Film. This storage medium works on an entirely different principle than either silver halide or diazo and while it does provide high resolution-low density images, it has not gained any substantial share of the microform market.

Reduction Ratio

In microphotography, the film image of the original document is reduced in size to the point that it cannot be read by the naked eye. Just how great this reduction may be depends on the size, detail, and contrast of the material printed on the original documents, and the legibility desired in the film copies. The size of the micro-images, as compared with the size of the original document, is expressed in terms of diameter, or reduction ratio. For example, when a reduction ratio of 18 to 1 (commonly expressed as 18:1 or 18X) is used, it is possible to reduce a document measuring 18 inches in length to 1 inch of film. More images can be recorded on the same amount of film by using a higher reduction ratio, thus resulting in film economy and a lower cost per item photographed. The reduction ratio, therefore, is the most significant measure of the storage capacity of a microfilm system. The factors governing the reduction ratio at which images are to be recorded in a given system comprise at least the resolving power of the human eye, the resolving power of the film, and the number of successive regenerations. It has been found that each successive regeneration of film copy retains only 80% of the resolution measurable on the previous generation. In practice, most users receive third-generation copies, but may occasionally receive 4th and 5th generation copies.

The greater the reduction ratio, e.g., the greater the number of images stored in a given area, the more difficult is the problem of indexing, locating, and accurately registering any single image. It has been estimated that the range of reduction ratios within which most applications for document storage and retrieval will fall is 15:1 to 40:1. Beyond these ratios a point is reached at which the cost and complexity of the image registration mechanism outweigh the benefits accruable to the higher reduction ratio. While the problems are less serious with a serial medium (such as roll film) than with fiche they are still a prime consideration.

Recording Densities

Present reduction standards for microfiche of 18-20X were based in part on available photographic techniques using planetary cameras. New developments, including computer-output-microfilm (COM), laser recording, and two-step processing with photochromic and conventional photographic techniques, provide a capability for increasing packing densities on microfiche to encompass four ranges of storage.

1. Low-Range. Conventional microfilm reduction of from 4 to 38X result in a maximum of 210 pages on a 4 x 6 fiche. The low range may extend to 42X, since computer output microfilm recorders appear to be able to operate at that reduction effectively. 42X should provide close to 250 pages per fiche.

2. Mid-Range. Reduction ratios of from 35 to 90X would provide up to about 900 pages. Present COM equipment provide the capability of generating microfiche at reduction ratios of 42-48X. This provides a claimed maximum of 450 pages. Indications are that the 50-90X range will be widely adopted for text documents, books, etc. Encyclopedia Britannica has adopted that range for its Library of American Civilization, to be published on microfiche. At least one other company has elected to use that range for its planned book publishing effort.

3. High-Range. Currently referred to as Ultrafiche. Reduction ratios of from 90 to 210X provide capacities up to about 2,000 pages per fiche. Current film limits are estimated at about 280X, or just under 3,000 pages per fiche. The high-reduction range to date has not proven to be attractive to a large number of potential users. This may change, as quality, price, and availability of equipment improves. The high-reduction fiche competes directly with cartridge film and with magnetic memory devices.

4. Extreme-Range. Reduction ratios from 280X to 1,000X or even higher are possible. Capacity has been estimated at up to 10,000 pages per inch at this range of reduction. Recording densities in this range can only be achieved by laser recording, bubble techniques, or other exotic laboratory techniques. These techniques may be used only for computer memory devices, or possibly for information retrieval devices.

Video

The use of electronic systems for recording, transmitting and displaying images by converting those images to electronic waves for transmission and reconverting them at the display point is a description in abstract terms of television or video as it is presently implemented. In the U. S., the standard monochrome and color composite signals (composite video signals include horizontal, vertical, and synchronizing components) employed in industrial and instructional video systems are based on a scanning raster of 525 lines interlaced 2:1 at 30 frames per second.

It would be useful at this point to compare, and distinguish between the technical characteristics of film and video presentations. These two media are distinguishable in terms of technical performance, production and distribution characteristics. Table 5 is a comparative listing of the characteristics of film and video production. As can be seen in the factors included in Table 5, both the product and the processes of film and video production have their positive and negative points.

Film	Electronic (Camera + VTR)
Storage of pictures, independent of TV - standard, optical projection possible.	Storage of signals, reproduction in the same TV - standard only.
Time required for processing.	Immediate replay possible.
Prints can be made in large quantities.	Copies: present-day method by re-recording.
	Contact print technique just coming up.
24 frames per second.	60 fields per second/30 frames per second.
Picture steadiness determined by mechanical tolerances (perforation)	Picture steadiness very good due to electronic stabilizing techniques.
Resolution and signal-to-noise ratio depends on film size and material.	Resolution and signal-to-noise depends on camera tube.
Quantum efficiency of the photochemical process limited. necessary light flux for equal depth of focus depends on film size.	High quantum efficiency of the photoelectric process. Necessary light flux depends on camera tube.
Materials with different transfer characteristics available.	
High contrast range can be met without anomal overloading effects.	Linear transfer characteristic in present-day pick-up tubes limits contrast range, overloading causes disturbing effects (blooming)
No lag effects (always new storage surface from frame to frame).	Disturbing effects in fast motion (lag and smearing)
Picture deterioration possible by dust, scratches, etc.	Picture deterioration possible by dropouts in video tape.
No colour registration problems, but colour errors possible due to multiple conversion processes.	Colour registration errors in the camera possible, good colour rendition because only one colour analysis process.
Film	Electronic (Camera + VTR)
	Immediate display and correction of recorded picture possible.
Equipment relatively simple and handy, inexpensive camera.	Complex and expensive equipment.
Storage material can be used only once.	Stored information can be erased, tape can be re-used.
Simple editing technique (picture information visible)	Present-day technique complicated and expensive.
	New developments on the way.

Table 5. Comparison of Film and Electronic Camera Production (Thiele et al, 1972)

Formats

At the present time video signals are capable of being recorded and retrieved in a large variety of ways; however, the prominent technique is the use of video tape. Video tape is magnetic tape with a composition and structure very similar to audio tape. Video tape differs from audio tape only in terms of quality and, in a limited sense, in size. Video tape is typically identified in terms of its width (e.g. 1/2 inch, 1 inch, etc.) because its other characteristics are either not prominent enough to be observable or not identifiable without special equipment. Available equipment for video recording is presently designed to handle five tape sizes, of which three have found broad application.

1. 2-Inch. The 2-inch format is the professional television format; this is the format used in all commercial broadcast television systems. Because of the complexity and cost of the equipment required to record and to playback material in this format, its application in instructional systems has been limited to those situations where the volume of production makes the cost reasonable and the distribution scheme is one designed for single source playback to multiple viewers - in other words a television broadcast system.

2. 1-Inch. The 1-inch format, while providing less sharp image than 2-inch, has been (up until recently) the advanced format towards which video manufacturers have guided their customers. The 1-inch format with its wider bandwidth (bandwidth seems to be a function of tape width - 1-inch tape has a bandwidth of 4 MHz while 1/2 inch tape runs about 3 MHz), smoother editing, higher resolution and better duplication quality has been a yardstick against which most instructional users have compared their own products or aspirations. While the tape itself is half the size of 2-inch tape, there are several other features which distinguish this format. In one-inch machines the tape is helically scanned (as opposed to being vertically scanned as in two-inch machines) by a single head (as opposed to two in 1/2 inch machines). The major problems with the respect to this format are the lack of any standardization or compatibility between recording and playback equipment manufacturers and the cost of the Video Tape Recorder/Player units. These factors, coupled with the increasing quality of 1/2 inch equipment, have served to reduce the attractiveness of the 1-inch format, particularly for individualized instructional applications.

3. 1/2-Inch. This format was initially introduced as the "amateur" format for video recording in somewhat the same sense that Super 8 film is considered to be an "amateur" in film format. However, the realities of the market have caused video system manufacturers to reappraise the amateur status of this format. Half-inch VTR system quality has been raised to a level which allows it to offer picture quality and production flexibility equivalent to available 1-inch equipment and to come very close to the levels achievable with a large percentage of the 2-inch systems still in operation. Resolution in excess of 300 lines and signal-to-noise ratios of 40 dB are available in models from several

manufacturers. The increased quality of 1/2-inch equipment, the significantly lower cost of 1/2-inch video tape and 1/2-inch recording equipment, and (most importantly) the standardization between manufacturers with respect to recording and playback characteristics make it the format of primary interest for individualized instructional applications.

4. 1/4-Inch. This format is presently available from only one manufacturer (AKAI) and is a system based on 1/4 inch tape. All the functional characteristics available in the less sophisticated 1/2-inch equipment are available. The major characteristic of this format that merits its treatment here is the fact that 1/4-inch video tape is no more than high quality audio tape and thus the cost of tape is almost 50 percent lower than equivalent 1/2-inch recording tape.

The major drawback of this format is that the available bandwidth on 1/4-inch tape is quite restricted. As a result the resolution, signal-to-noise ratio and overall picture quality are not equivalent to that possible with present 1/2-inch equipment. Continued development in this format does hold the promise of low cost, lightweight systems offering all the benefits of video recording and playback at a cost which would be extremely competitive.

5. Video Cassette. Over the last four years the concept of the video cassette has become one of the most heavily discussed concepts in the audio-visual community. The various video system manufacturers have vied with one another to provide the most spectacular press releases only to follow at some later date with contradictory or disclaiming releases on the same topic. The status of developments in this field is still unclear, the requirement and/or instructional application of the various systems is still undefined and the acceptance of the video cassette in an environment that does not fully utilize the video capabilities it presently has is questionable.

Despite four years of announcements, only two cartridge systems have been delivered to customers. The first of these, the Electronic Video Recording (EVR) system developed by CBS Laboratories, made initial deliveries approximately 18 months prior to this report. The system was based on a special film format from which picture information was extracted by an electronic scanning process and converted into a video image. EVR has since been dropped by CBS and the delivered units have been recalled. The second system to be delivered was the SONY-U-MATIC video tape system; developed by the Sony Corporation. This system has been adopted by three other large audio-visual manufacturers and is based on 3/4-inch video tape conforming to a new EIAJ standard (the first EIAJ standard was for 1/2-inch reel-to-reel machines). The 3/4-inch tape format has ostensibly been adopted to permit the packaging of one-hour's playing time in a reasonably sized package. The U-Matic format is a helical scan system with a field rate of 59.94 fields per second, providing 525 lines per frame, and is capable of both color and black and white recording and playback.

Other video cassette systems such as Panasonic's 1/2-inch cassette (similar in concept to Kodak's Super 8 cassette system), Phillips's 1/2-inch cassette, Ampex's Instavideo, and Cartridge Television's consumer tape system (Developed by Eumig of Austria) have been announced, demonstrated and publicized, but few have actually been produced.

Color vs Monochrome

Television systems have consistently been introduced as monochrome (or black and white) systems which then evolved into color presentation systems. This was true in commercial television, closed-circuit television, and in video tape systems. (Exception to this are the cassette systems which have opened with color as an integral part of the system.) The reason for this progression has been the fact that the acquisition, transmission, recording and display of color video signals is several orders of magnitude more complex than the same process for a monochrome system. This complexity, with its attendant development and sales cost, has retarded the adoption of color at each of the levels in the video hierarchy. Even today, the cost associated with color cameras (the most critical element in the video chain) has restricted color production almost entirely to commercial television - even though color recording and playback equipment is easily available in 1-inch, 1/2-inch and video-cassette systems.

The complexity and cost of color video recording can be attributed to the fact that color video requires that 3 discrete images be recorded (one in each of the 3 primary colors) and that these images be synchronized in such a manner that the appropriate color or color combination is dominant in each portion of the image as it is recorded or displayed. This requires, that in essence, 3 discrete imaging channels be used along with 3 discrete recording or display channels. The integration of these channels into a single camera, recorder, and/or display unit is the technical problem which has prevented the development of reasonably priced color systems except on a very slow evolutionary basis.

Kinescope

A Kinescope recording is the result of using motion picture film to record the imagery generated by a video system. Basically, a Kinescope recording system consists of a suitably modified (to compensate for the difference in frame rates between video and motion picture films) motion picture camera focused on a television picture table. The film resulting from this process is processed just as any other motion picture film. Kinescope recordings are suitable for screen projection or they may be used to present video programs at some point in time after their initial recording.

Generally speaking, 16mm Kinescope systems are the only ones that are commercially available. While Super 8mm film is capable of resolution in excess of what available video systems can produce, no systems for generating Super 8 Kinescopes have been developed to date.

Video System Developments

In addition to the video systems and equipment described in the preceding paragraphs, there are several aspects of video as a medium which warrant attention due to new or proposed developments.

1. Electron-Beam-Recording (EBR). A new technique for creating film based copies of video presentations, this system uses a proprietary electronic scanning system to convert the video signal into an image on the film without the use of either projection or camera optics. The advantage of such a system is that the picture quality of the original scene is conveyed to the film exactly as it was recorded by the original optical pickup system (less line loss). The impact of EBR on instructional video is, as yet, not specifiable, but it would seem theoretically that large scale adoption could result in superior film records of video presentations and subsequently higher quality reproductions for individual use.

2. Subscriber Response System (SRS). A true two-way television, this system developed by Hughes Aircraft Company is designed to permit selective control of incoming video information (much in the same manner as a channel selector), but with the added capacity to record all selections and viewing time at a central location. In addition, the SRS system is also provided with a two-way message capability which would allow the user to conduct a dialogue with the central computer system and/or its monitor. Depending on the applications for which it is selected, SRS could devolve into nothing more than a glorified dial-access system or it could become the transmission/communication subsystem of a sophisticated Computer-Assisted-Instruction system. Using the channel switching capability, interactive message capability, and data recording/display capability of the SRS, a central CAI system could service a large number of physically separated student stations of very low complexity and cost.

3. Video-Player. Another development which may impact the manner in which video presentations are generated and used is the announcement and demonstration by Kodak of a "feasibility model" of a video player. This device uses conventional Super 8mm film to produce a video image. In essence, this device is a miniature film chain using some form of electronic scanning to convert the film imagery into video signals. From the standpoint of video as a medium, the impact of this development is that it will allow video imagery to be acquired with extremely portable and economical equipment and yet be displayed with acceptable quality over conventional video equipment.

Audio

Auditory means of conveying information have been and will remain one of man's primary communication channels. In an instructional environment, the use of audible communication has evolved from the Socratic question-answer response mode, through mass communication-via-broadcast-media, and back to individual audio systems which supplement or supplant direct verbal communication from the instructor. Audio systems or subsystems (audio being defined here as the auditory portion and/or related equipment in any communication media) of direct concern in mediated technical training are those that record or store auditory information for use at some other time (as opposed to those which amplify, transmit or broadcast).

Based on Bretz's (1969) taxonomy of communication media, we are concerned almost solely with audio discs or records, and audio tape as the recording media having application in the AIS environment. While there are other forms of audio recording media, they are either out of use or serve specialized applications sufficiently dissimilar to instructional purposes that they do not merit further consideration.

Audio Discs (Records)

Audio discs or, as they are commonly called, records, are sheets of vinyl (in the case of limited use disposable forms) or polyvinyl chloride (in the case of commerical recordings) usually cut to a circular shape on which audio information is cut or pressed. The audio information takes the form of microscopic irregularities or changes in the walls of the grooves of the disc. In terms of sheer economics, disc recording and playback systems are found wanting in todays market, particularly for those applications where less than fifty copies are the norm. Production of audio discs requires the use of a "hot stylus" cutter using cellulose nitrate discs to generate "masters" and "stampers" from which playable discs can be obtained. Equipment for these processes are available, but their overall utility is limited and the market for small and medium volume audio reproduction has fallen to tape based systems. Generally speaking, the disadvantages associated with audio discs are the advantages of magnetic tape. Of particular importance in the technical training environment is the vulnerability of discs to noise, distortion, and damage.

Audio Tape

Audio tape is the prevalent form for instructional applications and will probably remain so for the foreseeable future. Audio tape is one of several types of magnetic tape, others include video tape, and computer tape. Differences between these are exclusively in terms of quality control during manufacture and in application. Briefly, magnetic tape consists of a backing material, a coating of finely divided iron oxide dispersed in a binding material which serves as the recording medium. During manufacture, the recording medium is caused to form evenly dispersed crystals oriented along the length of the tape.

a. Characteristics

1. Materials. The base material for audio tape can be of three types and can be obtained in four common thicknesses.

2. "Acetate" (Cellulose Triacetate or Diacetate). This base material represents the original form taken by magnetic tape and is still used in professional applications. Its major advantage is also its primary drawback: under stress the tape will snap rather than stretch. This allows for clean splicing and thus simple repair. However, since these tears occur with disconcerting frequency, and since the tape is damaged by excessive humidity, it is not particularly suited for instructional use.

3. PVC (Polyvinyl Chloride). This backing material is much stronger than acetate, but when subjected to stress, it will stretch too much for adequate repair. It is also sensitive to heat.

4. Polyester. This is the strongest form of tape backing available and in its "tensilized" or prestretched form its tendency to stretch is significantly reduced.

5. Coating. The coating material for magnetic tape is a metallic oxide (typically iron, but recently introduced as chromnium or cobalt oxides) and its performance as a recording medium depends on coating density and crystal orientation. The inherent signal to noise ratio of tape depends not only on the degree of dispersion of the oxide throughout the suspension medium (commonly 20-40%), but also on the surface quality.

6. Thickness. Audio tape thickness ranges from 1.5 mil to .5 mil with 1.5 representing so called "standard play" tapes, 1 mil "extended play" reel to reel tape and .75 mil being the standard tape thickness for tape cassettes.

7. Signal to Noise Ratio. The audio output from quality tape should be at least 50 db from the inherent noise level to the point at which distortion (3% of the 3rd harmonic) occurs on playback. Signal-to-noise ratio is measured in the following manner. A known signal level (333 Hz for example) is recorded on the tape, the tape is played and the output level is measured on a waveform analyzer. Once the overall output level is established, the tunable filter on the waveform analyzer is set to filter out the known signal level and the remaining audio output is measured. The ratio between the first and second measurements is the signal to noise ratio and, as stated above, should be at least 50 db for the gain setting at which audible distortion can be perceived.

8. Cross Talk. A tape characteristic of direct consequence in modern instructional systems is the susceptibility of the tape to "cross talk" between tracks on a multi-track recording. Cross talk is defined as the level at which a tone which has been recorded on one track can be heard on another. It can vary for different frequencies and the only effective preventive for cross talk is physical separation of the recording tracks. This separation is referred to as a "guard track." Its presence on a tape has several effects: it reduces or eliminates cross talk and reduces the number of tracks or the width of the tracks that can be recorded. In the latter case, the signal to noise ratio of the recording track(s) is reduced; however a solution to this reduction in signal-to-noise ratio is to use tape of higher sensitivity (e.g. so-called "high energy" tape, tape having a higher intrinsic coercivity, typically 500 oersted for "high energy" versus 300 oersted for conventional tapes).

Standards for acceptable level of cross talk vary with different frequencies, tape formats and applications. An acceptable level of cross talk for instructional audio tapes is 25 db between audio tracks and 50 db between audio and synchronization signal tracks.

9. Formats. The format selected for audio tape recording is governed by several factors - functional requirements, industry standards, physical dimensions of the tape, and available hardware systems. In the development of audio tapes for instructional purposes, there are no "industry standards" per se. Rather, there is a form of standardization imposed by the availability of recording and playback systems, economics, and certain basic functional requirements. In all cases, the actual tape format is determined by configuration of the recording head of the originating machine. In normal practice, the head configurations of all recording and playback units in a given system would be configured identically.

10. Half-Track Monaural. The most common format for audio tape recording in the instructional environment is half-track monaural (see Figure 10a). In this format, signals are recorded on about 4/10th of the tape in one direction with another track occupying an equal amount of space available for recording in the opposite direction. The remaining tape area serves as edge spacing and a guard track between the recorded tracks.

11. Quarter-Track Stereo. Quarter-track stereo is the next most common recording format and its head configuration differs as a function of the tape packaging used. In reel-to-reel recording, tracks 1 and 3 are recorded in one direction while tracks 2 and 4 are read in the opposite direction. In the four track cartridge (in reality a quarter track stereo cartridge), all four tracks are recorded in the same direction; recently introduced "Quadrasonic" or "Quad" reel-to-reel machines use this format also. In stereo cassette machines, track 1 and 2 are recorded in one direction and three and four in the opposite direction (Figure 10b).

12. Dual-Track Stereo. Two-track or dual-track stereo (see Figure 10c) results when two tracks corresponding in size to the half-track mono tracks are recorded in the same direction.

13. Other. While other formats, such as eight-track, are available, they require special recording equipment and are generally designed for specific non-instructional applications.

14. Packaging. Like so many other technological products, audio tape is available in a wide range of "packages" in which it may be recorded, stored and played. For instructional purposes, two of the available packaging concepts (reel-to-reel tape systems and the compact cassette) have established themselves as more or less the standard techniques for audio production and presentation. The obvious example of another packaging concept is the tape cartridge which has achieved qualified acceptance as a storage, distribution and playback medium.

15. Reel-to-Reel. Reel-to-reel tape handling systems, commonly using 1/4 inch tape, are sufficiently common so that no great depth of description is required. Suffice to say the major advantages accruing to reel-to-reel systems are greater capacity, higher fidelity on recording and playback (due to higher possible recording speeds) and more efficient editing capabilities. The major disadvantage lies in the requirement for student tape handling in an individually oriented system. All previously discussed formats are available on 1/4 inch machines. The only practical use seen for reel-to-reel systems in an individualized instructional system is in the initial production of audio materials for dubbing to more convenient packages.

16. Cassette. The compact cassette concept has come to be regarded as a standard. The compact cassette is an encapsulated double-spool tape handling system which after several different evolutions has been delineated by a set of dimensional and functional standards acceptable to a very large proportion of the worlds audio industry. The Electronics Industry Association (EIA) Standards Proposal No. 1082 established the recognized U.S. dimensional characteristics for the compact cassette, while EIA Standards Proposal No. 1067 establishes the recording standards of the compact cassette. Tape width in standard compact cassettes is 150 mil and length varies between 5 and 60 minutes of play at 1 7/8 inches per second. Compact cassettes and cassettes as a generic class are distinguishable from cartridges in that cartridges are defined as being single spool systems employing either an endless loop system or operating in conjunction with an external second spool. The size, ease of employment, and the wide variety of equipment employing this packaging concept make it an extremely attractive possibility as an instructional presentation form for Air Force technical training. Its major selling point is the simplicity of the procedures required to place it into or remove it from operation.

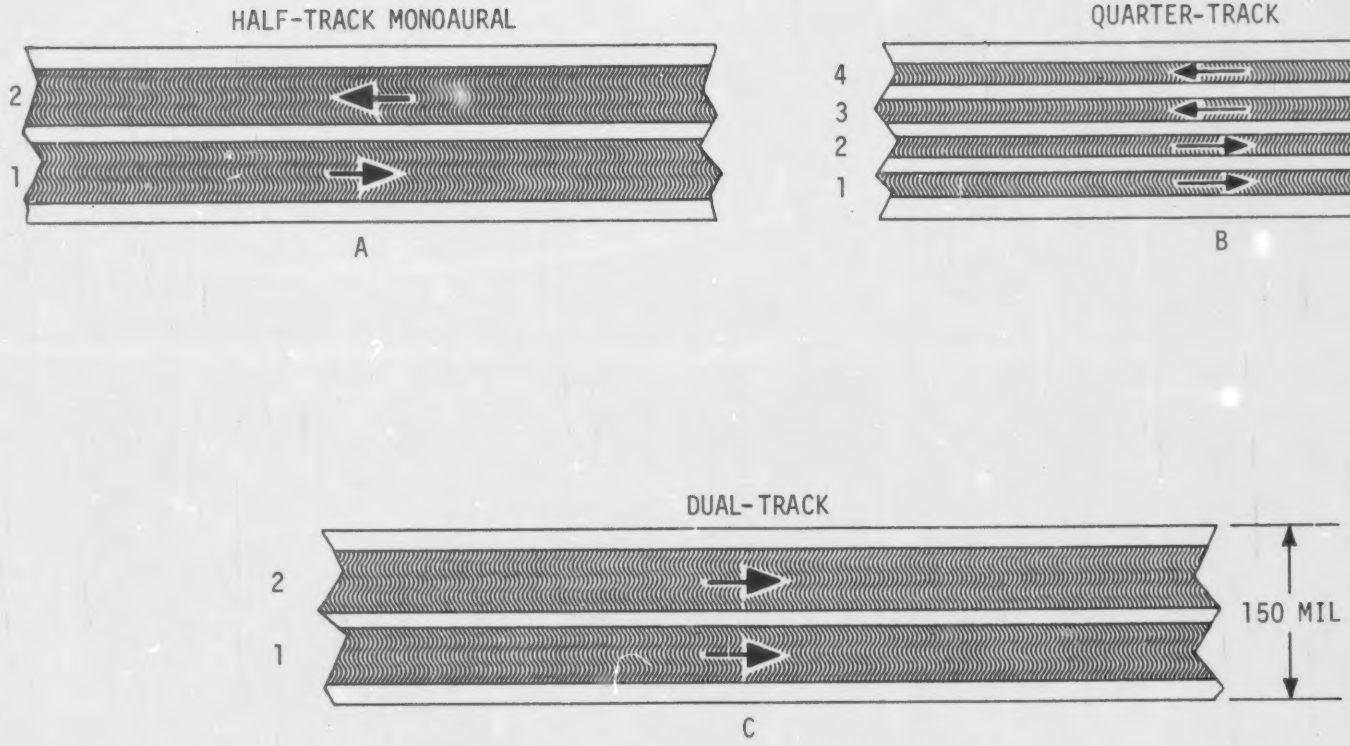

HALF-TRACK MONOAURAL
2
1
A
QUARTER-TRACK
4
3
2
1
B
DUAL-TRACK
2
1
150 MIL
C

Figure 10. Cassette tape formats.

17. Cartridge. The primary use of the cartridge to date has been in automobile playback systems. The cartridge contains 1/4 inch tape spliced into a continuous loop; the tape is typically recorded in a 4-track or 8-track format in which each track contains a separate program. This approach to tape packaging, while offering the potential for higher quality sound reproduction than the compact cassette, has not achieved the acceptance of the cassette. This lack of acceptance can be attributed to several factors, but primarily to the fact that there are very few commercially available recording systems for this format and that the cartridge is unidirectional - it cannot be rewound.

Broadcast Audio

The use of broadcast audio as an instructional medium is a somewhat difficult proposition to approach. The elements which constitute a broadcast system are present in many instructional applications, however, these are not normally considered instructional broadcasting. The use of instructional broadcasting in individualized training environment is limited by the conflict in the desirable goals of the two types of systems. There is, however, one exception. Through the use of multi-channel, it is possible to instruct a class of students in up to 16 discrete tasks. It is possible to instruct individual team members in the particular aspects of the team effort that they are expected to perform, as well as having certain channels operating at the regular instruction level while others are operating on a remediation level. In a wireless system this is all possible without any requirement that the student be at a particular instructional location. So long as the student is within range of the antenna, the receiver in his headset will pick up the signal for the channel he has selected.

Dial Access Information Retrieval Systems (DAIRS)

Dial access information retrieval systems are audio or audiovisual systems which consist of a centralized data store or bank that can be accessed by large numbers of students from any remote control device capable of exercising the switching mechanism which is the heart of the system. A dial access system represents an attempt at the centralization and control of the multiple sources of audio and/or visual information required to support individualized instruction for large groups of students. Unfortunately, while dial access systems do provide for this centralization and control, they do so at a cost which far exceeds the savings they produce, and, because of their limitations they do introduce some impediments to a truly individualized system of instruction which can only be solved with quantum increases at cost and complexity.

1. The Direct Access Technique. This option, which could also be labeled "Automatic Access" or "Student Control," permits individuals to gain direct access to the information desired by "dialing" a code number listed in a catalogue of programs. Access is automatic - usually by means of a telephone type switching mechanism - and immediate, provided the program has not already been dialed into use by another student. In most systems, if the program is already in use and the student wants to hear it from the beginning, he must wait until the last user has finished with it. For this reason, the direct access technique is used mostly for short, taped programs.

2. The Random Access Technique. "Random Access" is the ultimate goal of dial access systems. It describes a system whereby a segment of any program can be automatically retrieved for immediate use without waiting. Ampex produces a system which uses electronic dubbing techniques to give all users immediate access to any audio (or video) program with a maximum waiting period of only one minute. Chester Laboratories has produced a "Serial Information Dial Access Control System," called SIDAC, which permits users to listen to segments of a tape. This technique has obvious advantages over others but is more costly.

3. The Media Staff Technique. A more appropriate title for this option would be "Indirect Access Technique." The technique is no more than dialing the operator or attendant in the control area and asking him to play a selected program over which he has manual control. This is the usual way in which taped video programs are made available to individual users, since automatic access is too costly at this time. (Ampex's "Pyramid" system is the only other approach presently addressing remote access to a centralized video store.)

4. The Scheduled Access Technique. This option is employed to eliminate the waiting period from a simple direct access system. If different users, for instance, dial the same recorded program at the same scheduled time, all of them can listen to it simultaneously from the beginning without incurring any waiting time. A program schedule is particularly necessary if live programs are included in the system or if ETV programs are to be made available through the dial access system. Scheduled programs can either be manually operated or time-switch controlled.

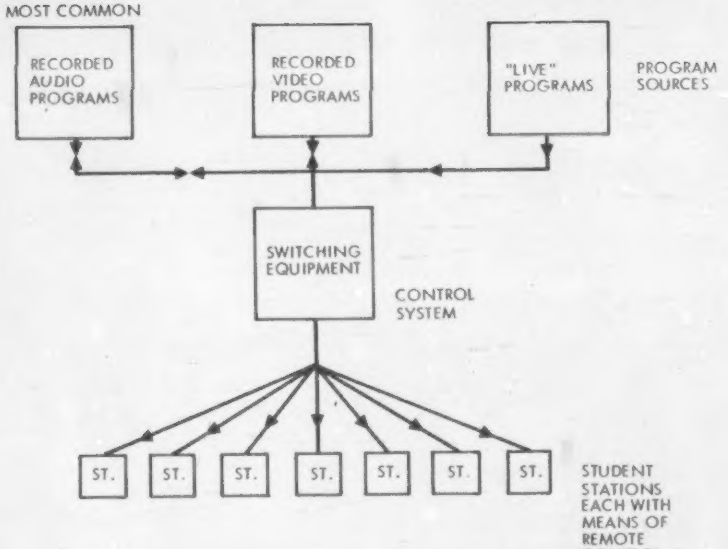
5. Restricted Access Technique. The techniques described above permit any student to dial any program. However, there are occasions when certain lines might need to be restricted from receiving programs - either because of the nature of the information or for testing purposes. One solution, using standard equipment, would

be to disclose the catalog or directory number of the test program only at the appropriate time. Or, if the selected system includes a stored-program computer as part of its switching mechanism, this technique can easily be programmed into the system, providing flexibility of randomly restricting any student position from receiving any program.

6. Master-Slave Technique. Sometimes it is necessary to remove the control of the student's station from the student. This can be achieved by means of a console which physically intercepts the wire between the student station and the switching equipment. If there is a computer switching control, the computer can be programmed so that any station can become the "master" (for use by the teacher) and any other stations can become the "slaves" to the master, receiving only the program dialed by the master.

7. Off-Campus Student Access. More and more schools are beginning to cater to off-campus students by extending their dial access systems through "recorder couplers" to outside telephone lines. By attaching audiotape recorders (which are scheduled to play at regular intervals) to telephone equipment similar to that used to handle weather calls, large-class lectures can be made available to off-campus students over their own telephones.

8. Summary. Of the techniques listed above, only the random access technique satisfied the requirements for an instructional system designed for individually paced instruction. (The above description of dial access systems was adapted from EFL, 1970.) Figure 11 is a schematic representation of a typical dial access system with the schematic for the more complex PYRAMID system shown for comparison. Given the state-of-the-art in dial access and electronic information systems, the establishment of a true random access system using a centralized information store is only possible with the use of computer based systems with their attendant complexity and cost. The only system which has presently achieved educational utility with this approach to audio-visual information storage and retrieval is Ampex Corp.'s Pyramid system. The high cost (70 K for a basic audio only system) and limited capabilities of this approach has led some developers of CAI systems (e.g. Bitzer, 1967) as well as those developing less sophisticated systems to the conclusion that the same levels of instructional sophistication (and perhaps even higher levels) can be achieved through the use of less complex and less costly locally operated systems. By developing instructional software and strategies which fully capitalize on the characteristics of presentation systems which are keyed to individual student control and local duplication, the same quality of material can be presented at a lower cost, with more flexibility than any available centralized system. Cassette libraries would be an example of this approach.


MOST COMMON
RECORDED AUDIO PROGRAMS
RECORDED VIDEO PROGRAMS
"LIVE" PROGRAMS
PROGRAM SOURCES
SWITCHING EQUIPMENT
CONTROL SYSTEM
ST.
ST.
ST.
ST.
ST.
ST.
ST.
STUDENT STATIONS EACH WITH MEANS OF REMOTE CONTROL (DIAL ETC)

BASIC COMPONENTS OF DIAL ACCESS SYSTEMS

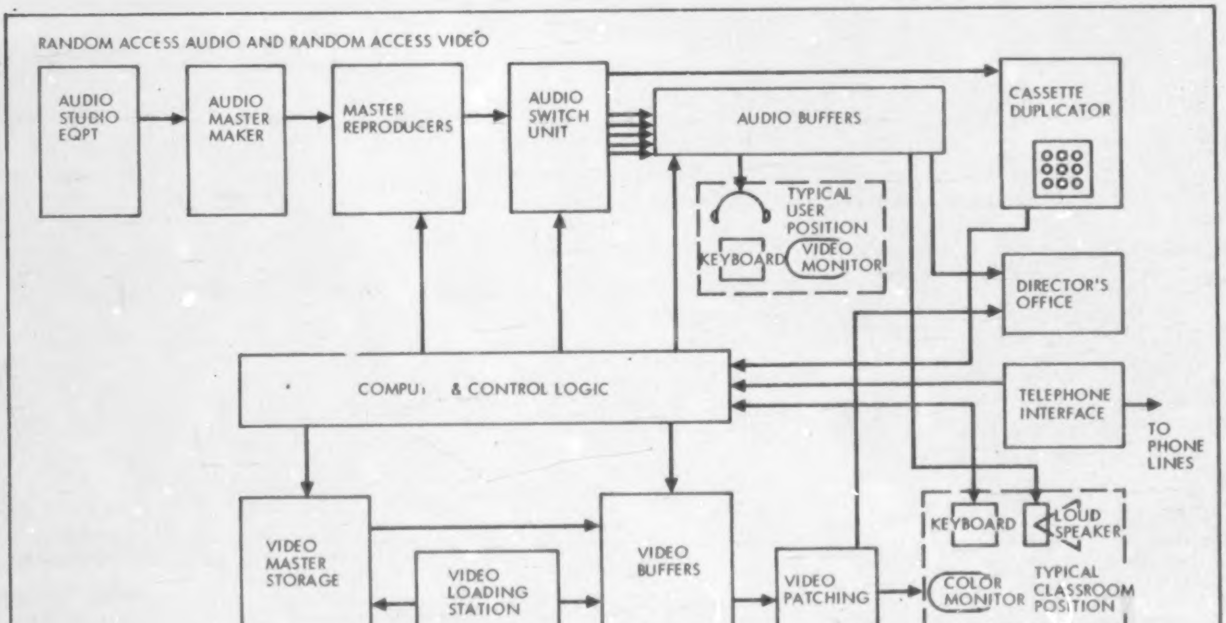

RANDOM ACCESS AUDIO AND RANDOM ACCESS VIDEO
AUDIO STUDIO EQPT
AUDIO MASTER MAKER
MASTER REPRODUCERS
AUDIO SWITCH UNIT
AUDIO BUFFERS
CASSETTE DUPLICATOR
TYPICAL USER POSITION
KEYBOARD
VIDEO MONITOR
DIRECTOR'S OFFICE
COMPUTER & CONTROL LOGIC
TELEPHONE INTERFACE
TO PHONE LINES
VIDEO MASTER STORAGE
VIDEO LOADING STATION
VIDEO BUFFERS
VIDEO PATCHING
KEYBOARD
LOUD SPEAKER
COLOR MONITOR
TYPICAL CLASSROOM POSITION

Figure 11. Pyramid system.

Synchronized Audio-Still-Visual

All of the still-visual presentation techniques described, with one exception, are dependent on external sources of audio information when and if audio information is necessary to supplement the visual presentation. The one exception is the Lincoln Laboratory Microform System with its integral sound track. All other existing still visual presentation techniques are faced with the problem of establishing and maintaining synchronization between a series of discrete static images and a dynamic audio data store. In most audio-visual presentation, this process is further complicated by differential audio message lengths and varying image display times. In order to accomplish this synchronization for still-visual systems, the audio-visual industry has evolved three basic approaches to the still image-audio synchronization problem.

1. Superimposed System. The superimposed visual/audio synchronization system consists of a low frequency (50 Hz) cue tone recorded with the audio program information.

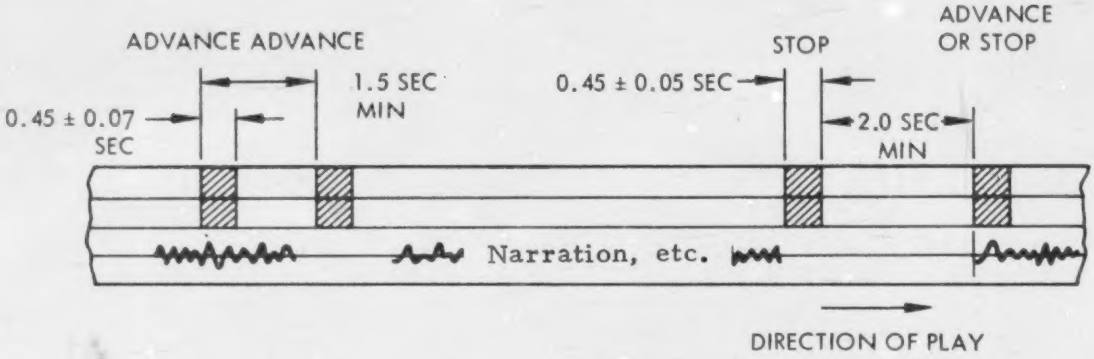
2. Separate Track System. The separate track system has the audio program information recorded on one track and cue signals in the form of tones recorded on a second track.

3. Digital System. The digital system has the audio portion of the information on one track and the control information recorded as digitally encoded pulses on a second track.

4. Summary. Of these three approaches, the last two offer the greatest degree of flexibility with respect to the number of functions that can be controlled. The first two approaches have been tendered as national standards to be adopted by American National Standards Institute. The compact cassette has become a standard in audio-visual applications. Most synchronization systems for individual audio-visual devices have adapted the cassette as well, thus, the configurations and constraints inherent to the proposed ANSI standard are partially attributable to the characteristics of the compact cassette. Considering the requirements inherent to a program of individualized technical training, the separate track system would seem to be the minimum acceptable synchronization capability. The separate track system is described in Table 6.

5. Kalart-Victor System. This system employs small tape cartridges mounted with each slide. When any slide moves into position for projection its associated audio tape is picked up by the playback apparatus of the specially designed mounting and playback mechanism. When the tape sequence is completely played the visual is extracted and the next slide/tape module comes into place. The system has a definite advantage with respect to maintaining synchronization between

Table 6. Separate Track Synchronization System


ADVANCE ADVANCE
0.45 ± 0.07 SEC
1.5 SEC MIN
STOP
0.45 ± 0.05 SEC
ADVANCE OR STOP
2.0 SEC MIN
Narration, etc.
DIRECTION OF PLAY

Cue Frequency Utilization

a) 150 Hz - Program stop or automatic switchoff

b) 1000 Hz - Advance of visual media, each cue advances the visual media one frame or slide

c) 400 Hz - Unassigned secondary frequency

d) 2300 Hz - Unassigned secondary frequency

Cue Duration

- Varies with application; standard given for 1000 Hz only: 0.45 seconds for slide and filmstrip.

Cue Spacing

- 1.5 seconds minimum between the leading edge of two adjacent advance cues.
- 2.0 seconds between end of stop pulse and next advance pulse

(Adapted from ANSI, 1973)

audio and visual sequences; however, this advantage is seriously jeopardized by several other characteristics of this system. The system is presently available from only a single source and is not compatible with any comparable system. Audio materials for the system can only be generated on the system itself and are not suitable for any form of multiple copy duplication. This system increases the storage volume for a slide set by at least a factor of three but is limited to use with 35mm slides.

6. 3M Sound-on-Slide System. In the Sound-on-Slide system, an audio disc is mounted in a frame which also holds the slide. This approach has the advantages and disadvantages that were ascribed to the Kalart-Victor design described above. This system is also limited to use with 35mm slides.

Training Devices, Real Equipment and Simulators

In the context of individualized technical training, there is another class of media that needs to be considered. If one considers that technical training represents a continuum on which the student progresses from a basic introduction to the subject area, to demonstrated proficiency in the criterion tasks, it becomes quite apparent that the instructional strategies required for this progression should include hands-on training. The specific media required to implement this practical training will vary with the content of each course and to a certain extent, within each block of the course. However, this training will employ one or more of the following media classes: training devices, simulation or real equipment.

Trainers

Taxonomy (adapted from Miller, 1960)

1. Knowledge trainer, with varying amounts of operational context, e.g., system trainers or mockups.

2. Skill trainers, with varying amounts of operational context, e.g., a manual dexterity trainer.

3. Single task trainers, with varying amounts of operational context, e.g., F-4 Gun System trainer.

4. Integrated task trainers, again with varying amounts of operational context, e.g., F-111 mockup used in the Weapons Mechanic Course.

5. Full mission simulators, with full operational context. (Not applicable to the baseline courses.)

Selection Parameters

1. The nature of the function which must be trained (e.g., task, skill, knowledge).

2. The amount of the task which must be trained (e.g., part-task, whole-task, mission).

3. The amount of the operational environment which must be included in the training situation.

4. The fidelity with which that environment must be reproduced.

5. The amount of branching which must be provided in the instructional sequence.

Discussion

The distinctions among trainers are indicated by their designations. Knowledge trainers teach required knowledges. A skill trainer teaches a perceptual, motor or perceptual-motor response which is part of a task, but not the task itself. The single task trainer teaches the entire task, but only one task (however one wishes to define task). The integrated task trainer teaches two or more tasks which must be performed simultaneously or sequentially. As the number of such tasks is increased, and as the amount of operational context incorporated into the trainer is increased, the integrated task trainer shades into the full mission simulator.

The reason for going into so much detail about the different types of trainers is that each has a particular use. Because their characteristics overlap and there is so much confusion about varieties of trainers, it is entirely possible to select an otherwise perfectly adequate training device for the wrong application. The various types of devices are differentiated primarily by the use to which they can be put and not by their hardware characteristics. For example, a part-task trainer may involve some degree of computerization or may not, in the extreme case, be mechanized at all.

It should be noted that the selection criteria do not exhaust the number of possible criteria, but they are the most important. In particular, they do not refer to hardware characteristics which are in fact secondary criteria for device selection. By this it is meant that if one specifies the function to be trained, the amount of branching required, the amount of operational environment, etc., one has by implication specified a particular class of training devices with associated hardware characteristics. The logical starting place for device selection is analysis of the training requirements imposed by the need to train a particular function.

Real Equipment

Real equipment or training equipment (if one chooses to use that designation for operational equipment used for training) is used quite extensively in all three of the baseline courses, both as a cost-effective alternative to the development of special training devices and to provide a maximum amount of functional context for these courses. This equipment is used almost exclusively in its original form. Little or no modifications have been made to this equipment although some modifications have been made to insure personnel safety. Examples of this type of training equipment are the automatic weapons used in the weapons mechanic course and the electronic equipment used in PME course.

Within the PME course, neither training devices nor simulators are used. Instruction and emphasis in this course is on the use and calibration of the equipment the student will face in the operational environment. PME practical training is designed to provide the student with the maximum amount of exposure to the same equipment and, to a large extent, the same environment (in terms of criteria, tolerances, equipment, etc.) he will encounter in the operational context.

The requirement for and, hence, the degree of emphasis on training devices per se, is minimized in the baseline courses. This is due to their inherent characteristics and because of the Air Force's training philosophy, which emphasizes the use of actual equipment under realistic conditions for these courses. Since the tasks mastered in these courses, and the equipment used in conjunction with these tasks are of such a nature that they are suitable for implementation in the present technical training environment, there is only a minimal requirement for knowledge, skill and single task training devices. Integrated task trainers are presently used in the weapons mechanic course, but their role is limited to backup of real equipment or to absorb scheduling overflow from that equipment. A specific exception to this is the F-111 Simulated Maintenance Task Environment which was developed specifically for the weapons mechanic course. It was designed to facilitate part and whole task training for weapons mechanic trainees in the loading and functional checkout of F-111 armament systems.

IV. MEDIA SELECTION PROCESS

Introduction

In approaching the selection of media to support a program of individualized instruction and in the matching of media to the instructional objectives represented by the baseline courses, the study team was faced with the problem of developing a logical and effective approach to media selection and assignment. Examination of the existing models, and techniques for media selection and assignment, lead to the conclusion that without exception, presently developed techniques are subjective in both their classification structure and in their assignment of values or relative rankings. Since this effort was aimed at the solution of a specific set of instructional design problems and was not intended as a research study for the evaluation and design of media selection models, the approach to the development of a media selection technique had to be a pragmatic one. Based on the stated objectives of this study an approach was selected which reflects both the systematic nature of our overall approach and the best features identifiable in the current literature.

Specifically, the study team adapted a modified form of Brigg's (1967) analytic approach and combined it with a molecular form of Bretz's (1971) decision tree technique. This combination was felt to provide a necessary and sufficient level of accuracy, without the requirement for intensive, molecular task analytic data for each instructional event, while still providing a more usable level of information than a simple ranking of "presentation flexibility." Once the particular media or media-mix has been identified, then the decision tree approach becomes extendable to the identification of specific modes of presentation.

Through the extension of the decision tree logic to include criteria of cost, logistics, and producibility, it was possible to select not only generic classes of media as appropriate to our functional and instructional requirements, but also to identify specific formats, packaging concepts, and even particular devices.

The details of this approach to media selection and matching are covered in the remaining portions of this section. The results of the media selection and matching analysis performed for this effort form the basis of the instructional environment design concept developed and documented in this report. The reader should be aware that the process described in this report and the instructional media derived as outcomes from that process are generalizable only to the extent that the new instruction shares the characteristics of the technical training courses which served as our baseline.

Assumptions and Approach

In approaching the overall problem of carrel system design, and the selection of media to meet the functional and instructional requirements certain assumptions were made.

1. The establishment of a high-fidelity representation of the task environment is not mandatory at all stages of training. The functional context of what is being trained is critical in the establishment of maximum rates of transfer at the completion of training. Extrapolating from the work done by Travers and others (Travers, 1970) it is evident that overemphases on "real" presentations may in fact degrade training performance by overloading the student's perceptual and discriminatory capacity. One of the critical tasks in the selection and design of mediated instruction (particularly in the context of technical training) is the isolation of those characteristics of the task which are necessary for training success. The selection of media and presentation forms which provide just this level of information will be more effective than a totally realistic presentation which overloads the student with irrelevant detail.

2. The composition and complexity of the task or skill to be trained determine the extent to which the concepts/information to be communicated are verbalizable. It follows that non-verbal learning is facilitated by visual presentations tailored to the composition of the task, while verbal learning is facilitated by auditory presentations paced by the student.

3. Media selection must be governed by a task-performance orientation to insure maximum transfer of training. This orientation has been found to provide a higher degree of motivation for students than more abstract or conceptual approaches (Carpenter, 1970).

4. Media characteristics, while insufficient by themselves as criteria for adoption or rejection of a given medium, represent the only logical basis for describing, categorizing and differentiating between media. It follows that the identifying characteristics for a given medium constitute the parameters upon which relative judgements of effectiveness and suitability can be made.

5. Differences between individual learners or groups of learners (e.g. low ability, high ability, etc.) are quantifiable on only two dimensions: speed and accuracy.

The implications of this definition of performance measurement in terms of media selection is that in order to facilitate the individualization of instruction, the media selected and the associated management systems must permit individually tailored control over the pacing of the instructional material while allowing for enough repetition, both between and within a given block of instruction to permit all students to achieve the established criterion levels.

Having established these assumptions upon which carrel system media selection is to build, the question of how to select the media to be used follows quite directly. The point has been made by Briggs (1970), among others, that there does not exist any definitive approach to, or model of, the media selection process which can be applied in the manner of an exposure guide or screen size table. Lacking a firm quantitative or theoretical base upon which to build a media selection technique or procedure has given rise to several abortive attempts to develop quick and easy tabular systems wherein one could simply enter whatever behavior/task/skill/knowledge he wished to train and obtain the medium or media best suited for that training. A number of researchers (Allen, 1967; Parish, 1966; Meister & Sullivan, 1970 among others) have attempted to develop a media/task characteristic taxonomy which would list both commonly known and usual, or potential features, stimulus dimensions, etc. Further research in the field has, to date, failed to generate such a taxonomic structure. Cotterman (1958) and Gagne (1965) have postulated different taxonomies to classify human learning behavior, but these have also failed to find significant applications.

The taxonomies described above are attempts to relate two or more disparate phenomena. The problem arises in that taxonomic classification presupposes an underlying relationship between the items being categorized, and this relationship is a "given" to those doing the classification. Unfortunately, in the fields of instructional technology and educational psychology, there is little or no definitive research that demonstrates conclusive casual relationships between instructional presentation's and learning. While Aptitude - Treatment - Interactions have been hypothesized, little or no evidence can be identified which is generalizable to an overall taxonomic structure.

Lacking a suitable existing taxonomic structure upon which to make our media selection decisions, it became necessary to develop one. There are, at least, two possible ways of classifying pheonomena as disparate as those which form the crux of the media selection process. In the first, each phenomenon can be classified separately and then rules or principles relating the discrete phenomenon can be developed to equate them. In the second, the phenomena can be classified in terms of a common set of categories, thereby equating them. This second approach, requiring fewer assumptions and steps, was the one selected for application to this program.

As stated in this report, the approach to the problem of media selection is the same type of iterative, logical process which characterizes the approach to the overall carrel system design problem. Figure 12 represents the logical processes defined in succeeding pages. The details of the analysis technique used are not necessarily germane to this report. Qualitative task analyses were performed for each of the three baseline courses, the types of tasks, skills and knowledges which constitute criterion performance for each course have been

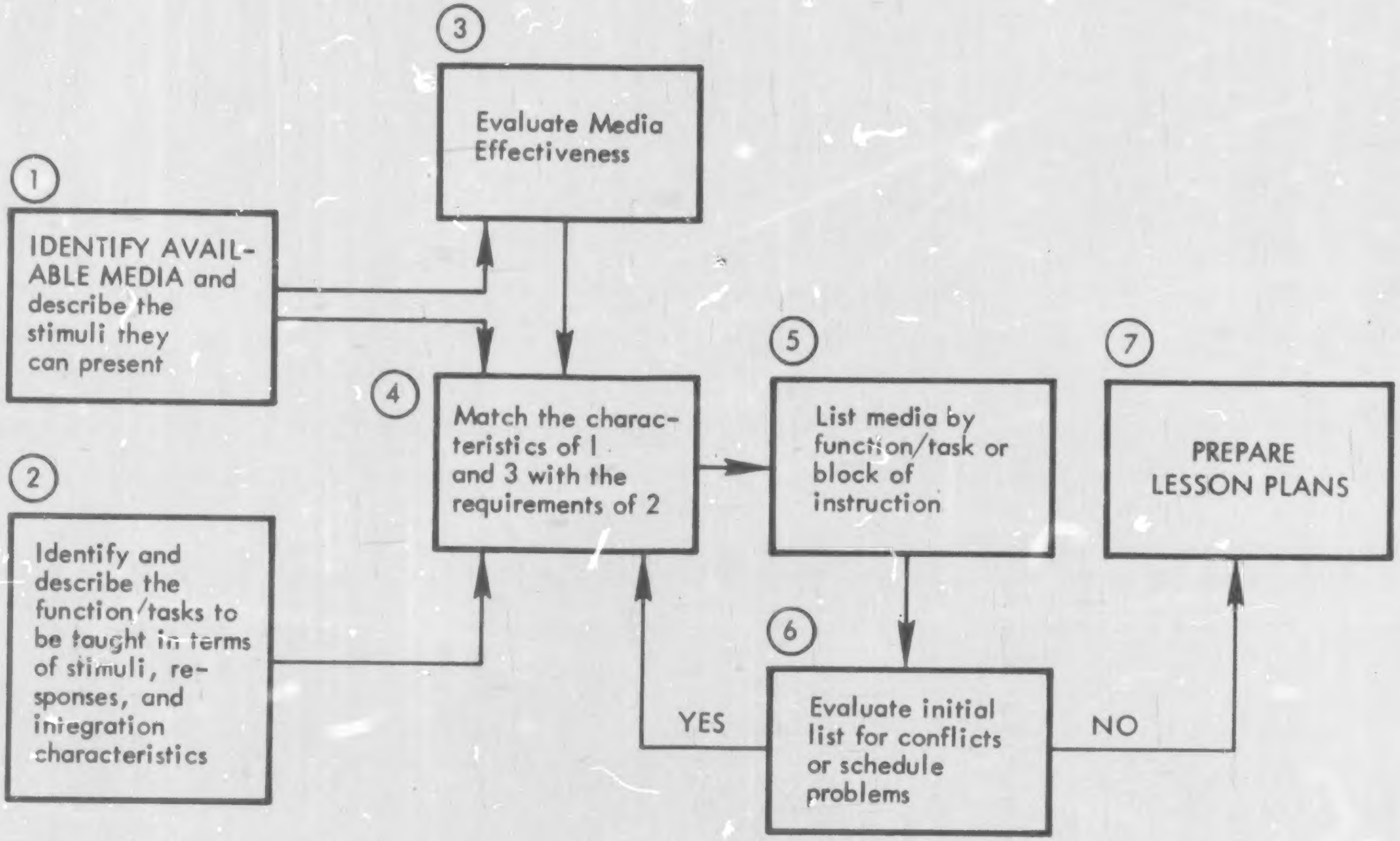

①
IDENTIFY AVAILABLE MEDIA and describe the stimuli they can present
②
Identify and describe the function/tasks to be taught in terms of stimuli, responses, and integration characteristics
③
Evaluate Media Effectiveness
④
Match the characteristics of 1 and 3 with the requirements of 2
⑤
List media by function/task or block of instruction
⑥
Evaluate initial list for conflicts or schedule problems
YES
NO
⑦
PREPARE LESSON PLANS

Figure 12. Model for media identification and selection.

identified, and the types of stimuli, and information processing behaviors have been extracted and analyzed. Based on this analysis, the stimulus, response and processing characteristics for each task, block of instruction, and course, were synthesized into a generalized set of learning behavior characteristics which were interpretable in terms of a set of media characteristics which is seen as the necessary and sufficient set required to discriminate between media.

Functional Requirements

The functional requirements for each of the three baseline courses are summarized in the following paragraphs. These requirements represent an interpretation of the pertinent instructional and environment variables operating in and on the baseline courses as they are presently structured and administered. While the conversion of these courses to a regime of mediated individual instruction might conceivably result in significant functional changes, the nature of these changes was not assessible at this point in time. Thus, the analysis and design efforts had to proceed in terms of the functional requirements which could be defined.

Inventory Management Course

The essence of the tasks performed by the Inventory Management (IM) specialist is that which is central to almost all clerical tasks: data is acquired and stored in one form and at some later time, usually in response to an external cue, that stored data is retrieved, transferred, either intact or after transformation, to another storage or transmission medium. In the Air Force inventory management system, the data of concern are such things as federal stock numbers, part numbers, etc. This data is stored, retrieved, transcribed and transmitted by the inventory management (IM) specialist.

The IM specialist's training is designed to allow him to identify specific data sources, extract data from them, prepare that data for transmission in accordance with prescribed rules and regulations, and to transmit that data to the proper recipients. The medium in which the IM specialist operates is almost exclusively paper text.

The largest percentage of present instruction is provided via the group-paced lecture/demonstration method. Conversion of this course to individualized instruction involves consideration of the following factors:

1. Development of an approach to, and selection of media for instructional materials presentation which will enhance skill performance in training and maximize transfer to the operational situation.

2. Selection of instructional approaches and media presentation techniques which will maximize student participation.

3. Concentration on instructional designs which enhance student interest in the tasks to be performed and in the IM career field.

Design of the instructional environment for the IM course is complicated by the fact that, in addition to the factors of the military training environment and widely diverse student population, the skills to be trained in the IM course are clerical in nature and, thus, share all the problems associated with the development of superior clerical training in any other organization. Clerical training, generally speaking, is awkward to approach instructionally because of the inability of the training situation to provide realistic feedback.

The key to successful individualized instruction in this environment is the development of a presentation system which is capable of providing the student with direct task-related information in the context in which the task must occur and also provide specific task-oriented feedback. Because of the nature of the tasks being performed primary stimuli would have to be provided visually with aural stimuli serving supplemental and confirming roles. Visually displayed stimuli do not require motion as an integral factor, however, the use of dynamic sequences for emphasis or attention getting would seem to be a definite possibility. Student participation in the actual learning process should be accomplished through direct interaction between the student and the specific forms of instructional presentation. Ideally this would be accomplished through the design of the presentation hardware, however, it is also possible through effective software design.

Precision Measurement Equipment Specialist

Analysis of the present content, methods of instruction and objectives of the precision measurement equipment (PME) course provides evidence that more extensive use of mediated, individualized instruction would be both practical and effective. Analysis of the instructional objectives and specific tasks trained in the PME course indicate that the major emphasis is on procedural and fine psycho-motor learning.

The PME course represents an extremely complex mixture of cognitive, psycho-motor, and perceptual learning. As such, the requirements imposed in terms of mediation are extremely severe.

The media type(s) required to support each block of instruction varies from block to block as a function of the level of understanding and performance expected from the student.

The study teams concept postulated that still-visuals synched to an associated audio presentation would be both effective and efficient in satisfying the objectives of Block 1 and the introductory lessons of the remaining blocks. The information content of most of these blocks is at such a conceptual level that the use of good graphics, high resolution imagery, and, if required, simple animation, should be adequate. To reinforce and/or supplement these visuals, there is a requirement (particularly in Blocks 6-15) for dynamic presentations to provide higher fidelity representations of the sequences of events and/or the dynamic nature of the phenomena under study.

Weapons Mechanic (TAC)

Analysis of the specific tasks and instructional objectives inherent in the weapons mechanic (TAC) training program indicate that the primary burden of instruction in the first three blocks of instruction could be carried by still-visual presentations with accompanying narration. The introductory lessons in the remaining blocks of instruction could also be supported by similarly mediated instruction.

In order to support the hands-on portions of Blocks IV-XII, mediated instruction presented by conventional means is inappropriate and insufficient to satisfy the demands imposed by the nature of the tasks to be performed and the environmental conditions in which they are to be performed. All instruction, tasks and learning, in these blocks is oriented to the individual's performance as a member of a two, four or five man team. While it is conceivable that instruction could be designed so that both members of a two man team could receive the same instruction, the effectiveness of such an approach for four and five man teams is doubtful. Thus, in the latter blocks of the weapons mechanic course, mediated instruction must occur in several discrete forms. It must at least provide an orientation to the tasks and skills to be mastered by each member of the team as well as providing specific instruction to each individual team member.

Media Selections and Strategies

To meet the instructional objectives, and to train the specific task behaviors inherent in the operational characteristics of the three baseline courses requires a mix of instructional strategies, styles and media. To meet the constraints and desired parameters described, the basic functional requirements for an individualized, mediated program of instruction are defined as follows:

1. A system for the presentation of still-visuals in both parallel and sequential fashion

2. Audio presentations aimed at single individuals and teams of two, four and five members

3. A capability for synchronizing audio and visual presentations

4. Provisions for displaying dynamic sequences when required

5. Design features which require active participation by the learner in the instructional process

Design solutions addressing these functional requirements are addressed conceptually in the following paragraphs, while specific implementation of these concepts are discussed in this report.

Still-Visual Presentation Component

The requirement for a still-visual presentation system is common to a large percentage of the instructional events in each of the baseline courses. Having established such a requirement, the next question quite obviously becomes - what are the desirable characteristics of such a presentation system?

The analysis and definition of media characteristics established that the 35mm slide, 35mm filmstrip and 16mm filmstrip were among the most common forms of projected still visuals available and that photographic prints represented the most portable form. In designing an instructional environment for individual study in the types of tasks defined previously, it is accepted that projection of the visual image has certain intrinsic advantages (such as attention-focusing and pacing) which make them more effective than printed imagery. Working from this hypothesis one can specify certain functional and logistical attributes or preferences with respect to how a system should function. Based on our decisions at this point in the design process, one is faced with the mechanization of whatever projected still-visual format selected.

Trow & Smith (1965B) established the instructional advantages inherent in a rear-projection system (vs. a front projection system) in the individual study environment, the optical advantages to such configurations are spelled out by Vlahos (1968) and Smith (1970). These studies and other research have established a precedent in the design of still visual presentation devices for the use of rear projection. Given the environmental constraints described in this report, it is felt that a rear projection system is best suited for the system under design here.

The second most prominent characteristic to be considered in the design of a still-visual presentation system for the baseline courses and attendant behaviors is the prominent need for multiple images, presented either in parallel or in sequence. The instructional requirements for a multi-image presentation capability are based both in the information transmission and in the motivational characteristics of the instructional process. With respect to the transmission of information, the use of multi-image presentations allows the student to perform comparisons. The use of multiple images also allows the instructional designer to establish spatial relationships and simultaneous views from different angles or different degrees of magnification. Multiple image presentations are ideal tools for teaching the detection and identification of subtle changes. Given these advantages, as well as the motivational advantages accruing to novelty, abruptness, visual richness and presence, the use of a multiple image presentation format has definite instructional advantages.

Selection of a specific image storage and display medium is a multifaceted problem. The specific parameters which affect this decision have been discussed in this report. In selecting the image storage and display medium for this particular instructional environment, consideration was given to all the factors described in the previously cited section and the following choices were made:

1. For those applications where the instructional content is conceptual or procedural material and changes infrequently, filmstrips were selected as the storage, display, and distribution medium.

2. For those applications where the instructional content changes frequently, and during those periods when instructional strategies, content or presentation techniques are undergoing evaluation, 35mm slides were selected.

3. For those applications where the requirement is for storage, retrieval and display of large amounts of procedural and other types of textual data for simple reference, review or remedial study, microfiche, 4 inch x 6 inch size, using the present COSATI (Council on Scientific and Technical Information) format at 24 to 1 reduction ratio was selected.

Audio Presentation Component

The audio presentation component of our overall instructional system design was seen as serving two purposes: the audio component was seen as primarily providing complementary and supplementary information. Its secondary application was to serve as the primary mode of stimulus presentation in those environments where visual presentations were neither possible nor practical.

Implementation of the audio presentation component's primary role requires that the audio material be as available and as accessible as the visual material. Thus based on the results of our analysis in this report, the tape cassette represents the most logical choice as the storage, presentation and distribution medium.

In its second major role (stand alone audio presentations) the audio stimulus material would continue to be stored on compact cassette, however, the stand alone mode would be implemented in two different ways. The first of these would be the use of audio instructional materials in the study carrels. This would be implemented through the use of a library of cassettes and the existing audio component in the carrel. The second method would store the audio information on cassettes, however, they would be transmitted via a wireless FM transmitter receiver system terminating in a receiver headset worn by the individual student. Through the selective use of various channels and channel combinations, it would be possible to provide individual instruction to each member of a team and/or provide for normal, accelerated and remedial instruction on the same set of tasks.

Audio/Visual (A/V) Synchronization Component

Development and selection of the Audio/Visual (A/V) synchronization component of the overall instructional system was predicated on the assumption that a 2-channel information transmission system (Audio and Visual) offered a substantially more effective instructional environment than a system which relied on either alone. Having established the requirement for combined audio/visual presentations, the problem which required solution was the selection of techniques for implementing such presentations.

In the design of our primary modes of presentation (still-visuals as filmstrips or slides, and tape cassettes), the question to be resolved is the matter of maintaining synchronization between the visual and audio presentations. This synchronization is both a physical and instructional problem. The question to be resolved is how to tell the image system and/or audio system to advance, hold, or repeat itself. The solution selected for our application, while sharing features which can almost be considered a standard in the A/V industry, does possess certain unique characteristics. The synchronization system for still-visual presentations is designed to support visuals stored as slides and/or filmstrips. It is not capable of providing audio synchronized to data stored on microfiche. The system uses the tape cassette as the medium in which audio presentations are designed to provide the narrative which provides context and relationships between individual images. Since the visual presentation component is a multi-image system requiring multiple projection devices synchronized to the tape cassette system, the minimum amount of synchronization required of this component involves control of the Projector 1 Advance, Projector 2 Advance, and the Tape Presentation Hold.

Audio tones of specified duration, frequency and amplitude, recorded on a separate track from the audio material were selected as the signals most suited for this particular application, offering both a higher degree of reliability (with respect to proper functioning) and more flexibility (with respect to possible frequencies and combinations of frequencies that can be used) than is available in systems relying upon sub-audible pulses in the audio data track.

Dynamic Presentation Component

Our analysis has shown the instructional value of dynamic visual presentations for those behavioral objectives in which the motion is directly related to proper mastery of the tasks being trained.

There exist two primary problems in the structuring of instructional events employing dynamic presentations. The first of these is: when is it most useful? Secondly, once having decided to use it as a presentation form, in what manner shall it be displayed? The answer to the first of these problems is situation dependent and is affected not only by the accuracy and diligence of the instructional analyst in examining the instructional requirements of a given task, but also by the talent and capability of the software producer. In certain instances, the functional characteristics of the task and its context may not demand motion as a presentation quality, however, the software producer by capitalizing on the capabilities of either the video or motion picture mediums, can stimulate behavioral changes beyond what could be accomplished by still frames, texts and/or audio alone.

The answer to the second problem is somewhat more concrete. For the instructional system developed in this project, economics and the present quality in film based systems favored the selection of Super 8mm film with an integral magnetic sound track. The relative low-cost of this medium, with respect to all facets of production, display and distribution, combined with its picture quality at moderate image magnifications, make it extremely attractive for individual and small group instruction.

Television or video presentations share many of the characteristics of motion pictures, however, their use in the past has been limited by the lack of adequate resolution, color rendition, and the economics associated with broadcast and reception facilities. With the introduction of low cost video tape players and the recently introduced video cassettes, at least the cost and logistics aspects of video presentations have become manageable. However, overall economics continue to favor Super 8 film based systems except where the immediacy of television is required.

The selected approach to the presentation of motion picture sequences in support of individualized technical training is to provide the film in a convenient, easily manageable form for use in stand alone systems. The use of video in the context of Air Force technical training is discussed in this report.

Student Interaction Component

Student interaction with an instructional system can occur at two levels. These levels of interaction are defined as being either passive or active. In the passive mode, information transmission is essentially a uni-directional process - from the presentation medium, information flows to the student. In the active mode, the system is designed not only to convey information to the student, but also to elicit some form of overt response from him.

Generally speaking, all media are inherently passive transmitters of information; it is only through intercession of the instructor and/or the use of specifically designed software that any media can approach the active level of student participation in the learning process. In those instances where there is active participation by the learner, the interaction is usually one of two types - "selected" or "constructed." Selected responses are commonly described as "objective" and are typified by the true-false and multiple choice test situation. The application of these techniques to individualized or mediated instruction has a long history and is presently epitomized by the mechanical and electronic response systems presently enjoying a renaissance in technical training circles. Constructed responses can occur in either written, spoken, manual or typewritten forms (Trow & Smith 1965B). Examples of the written form are programmed texts of the Skinnerian type. The spoken form of response is typified by the vocalized responses required in language training. The manual form of constructed response covers a wide range of possible situations. The most common form associated with technical training is a modified form of the Skinnerian approach in which instructions are given and then the student is directed to complete an action (e.g., soldering a connection). Upon completion of the required action, the student restarts the system. The fourth type of constructed response involves the use of a computer based system or manual simulation of some form in which the student's response is entered as alphanumeric data via an electronic keyboard. This data is analyzed by the system using specifically developed algorithms which are capable of selecting correct or partially correct answers from those which are incorrect.

Given these possible alternatives, passive versus active and the various forms of active participation in the learning process, the question to be addressed during this study was, of course, which alternatives are most appropriate and feasible for this particular application? In response to that design problem the following mix of active participation was selected. First, of course, passive interaction with any learning system cannot be avoided. There are sequences of information that the student must simply experience (e.g., introductory lectures, rules and regulations, etc.) which simply do not warrant any more complex efforts than simple presentation. Active participation in the learning process will involve the use of selected responses and manual responses.

Any one of the available approaches pursued independently will allow you to posit a solution, but the validity of that solution can and should be questioned. The approach employed in this program has been specified earlier. It can be summarized as a systematic examination of all factors impacting upon the design of the constituent parts of the instructional system, using analytic techniques and particular talents having direct relevance to specific aspects of the design problem. Individual study spaces have been and are legitimate areas of concern for architects, industrial designers, furniture designers, instructional technologists, human factors and industrial engineering personnel. Each of these disciplines has its approaches and its own goals in approaching the study space design problem. What we have attempted to do in this study is to synthesize the findings and approaches from several of these disciplines into a coherent set of findings which would at least define the parameters impacting the design of instructional environments.

In developing alternative solutions to the problem of designing suitable instructional environments for use in Air Force technical training, certain parameters and limitations were imposed which impacted not only the design solutions, but also the approach to them. For clarity, it seems worthwhile to reiterate those parameters and limitations prior to describing our proposed solutions.

Design Parameters

1. An instructional environment or environments shall be designed for all phases of training in the three baseline courses.

2. These instructional environments shall be designed to facilitate self-paced, individualized instruction.

3. Consideration will be given to the development and/or selection of media systems which are compatible with computer control or computer management.

4. The instructional environment resulting from this study should provide for remedial instruction, information retrieval and display, and the evaluation and assessment of student performance. In addition to these functional requirements, the resulting instructional environment must provide for the requirements inherent in the hands-on performance portions that constitute the core of the three baseline courses.

5. Attention will be given to the development of an effective and efficient system of multiple carrels with particular emphasis on the development of physical configurations and communication between carrels, and, between carrels and other portions of the learning environment.

6. The resulting learning environment should be capable of functioning within the constraints and limitations imposed by existing physical space for the baseline courses.

7. Media equipment selected for the use in the system will be limited to presently available hardware systems.

Accepting these as the parameters within which solutions must fall, several alternative configurations were prepared which seemed to meet the functional, administrative, economic and physical characteristics inherent in the design problem. Figure 13 shows the components which interact in the specification of an instructional environment.

It should remain clear, however, that the instructional carrel system developed here is only one portion of the overall individualized technical training system. The components described in Figure 13 may very well dictate design solutions which are not amenable to mediation or inclusion in any specially designed instructional environment.

Selected Media

As stated in this report, the following media were selected for inclusion in the AIS instructional environment:

Filmstrip (35mm or 16mm with sound). This is the primary media form, selected to serve as the instructional presentation for the bulk of all three baseline courses.

Selection Factors. Functional capability of the medium as a still frame and slow speed moving image (still frame movie or slow speed animation) display. Reliable equipment of varying sophistication allows the system to be tailored to meet space, financial or functional constraints. The economic advantages attendant to these formats as storage and distribution medium were also significant.

35mm Slides. Ancillary media format, selected as the developmental and prototype medium; can also serve as backup to primary media.

Selection Factors. Availability, familiarity, ease of revising single slide sets. Economics of production for prototype work.

Audio Tape (Cassette Loaded). Supporting media form to the filmstrip, provides multi-sensory stimulation through the presentation of complementary information. Also serves as source of control signals for pacing of presentation.

Selection Factors. Proven superiority of visual and audio presentations over either form alone; availability of reliable equipment; "standard" packaging concept, ease of production, storage, duplication and distribution.

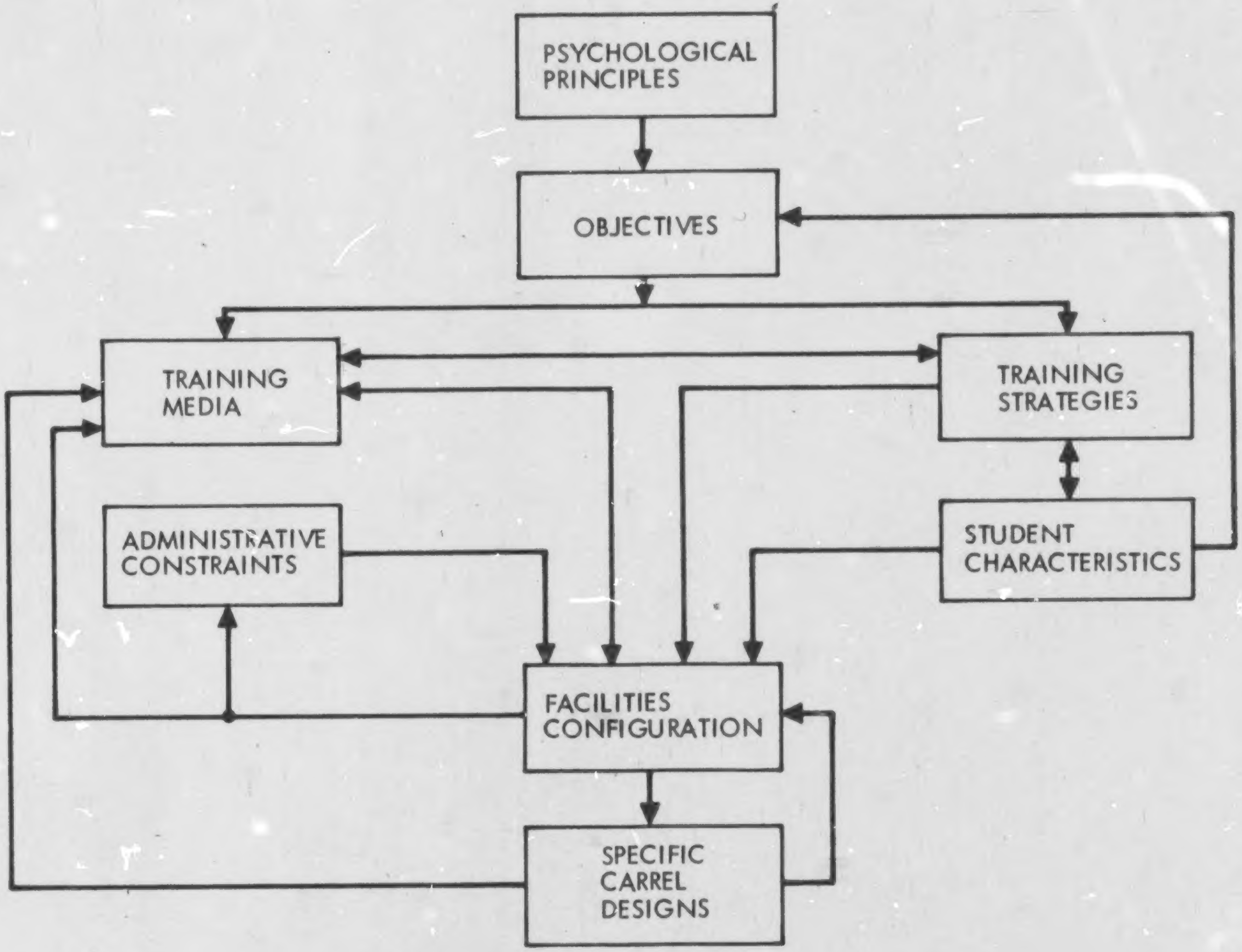

PSYCHOLOGICAL PRINCIPLES
OBJECTIVES
TRAINING MEDIA
TRAINING STRATEGIES
ADMINISTRATIVE CONSTRAINTS
STUDENT CHARACTERISTICS
FACILITIES CONFIGURATION
SPECIFIC CARREL DESIGNS

Figure 13. Instructional environment components

Super 8mm Movies (Cartridge Loaded W/Sound). Supplemental media form, selected to alleviate tedium resulting from continual exposure to a single format of presentation. Would also serve as media for remedial instruction.

Selection Factors. Motivational connotations of film presentations; availability of easily operated, stored, and reliable display equipment; economics, storage and distribution factors.

Microfiche. Media for information retrieval system, selected primarily on the basis of the present availability of manually and digitally addressable storage and retrieval systems. Will serve as the storage medium in the information retrieval subsystem and may, if present experimental efforts are successful, evolve into an instructional medium. Will also be used to present prototype or draft textual material.

Selection Factors. Availability of display equipment meeting functional requirements, producibility, economics (particularly of revision), portability and potential.

Having selected this spectrum of media as the basis of instruction in the instructional environment to be designed, the next event had to be the development of an integrated system of control, presentation, storage and environmental control. The process of design need not be reiterated here. It is sufficient to state that the instructional environment described below is the result of a systematic examination of the functional requirements, design constraints and possible solutions to each element of the total design. This approach resulted in the system configuration described on the following pages.

System Description

In the development of individualized instruction, almost all of the attention to date has been focused on the development of the instructional materials themselves. To a lesser degree, equipment manufacturers have proceeded with the development of hardware which has been marketed as "instructional" in nature. The extent to which the true instructional value of these hardware systems has been determined will not be questioned here.

In order to develop an instructional environment tailored specifically to the requirements of Air Force technical training and particularly to the three baseline courses, we have attempted to take a fresh look at the entire instructional facilities/environment problem. The approach was to delineate each of the modules which comprise the instructional environment as a system, to treat each of these modules as a discrete design problem, and then, integrate the solutions of each of these discrete system design problems into a viable whole. In defining the modular elements which comprise the instructional environment, four separate modules have been identified as constituting a necessary and sufficient set. These modules are: (a) working surfaces, (b) information display and presentation, (c) structural, and (d) services.

In the following paragraphs a capsule description of solutions to the design of each of these modules is provided; details of system design are contained in the remaining parts of this report.

Working Surfaces

In establishing the requirements for working surfaces and associated areas for individualized technical training, no single solution would adequately serve the variety of tasks inherent in the baseline courses. Rather than effect a compromise in the form of a marginal work surface common to all applications, the concept of the work surface as simply a platform upon which activities could be performed was accepted. Acceptance of this generalized concept of what constitutes a work surface allowed continued use of certain existing training hardware (specifically the worktables used in blocks III, IV, & V of the weapons mechanic course and the work benches used throughout the second half of the PME course) while accepting a series of cleaner solutions to the remaining instructional situations.

The work surfaces that have been retained, have been selected on the following rationale: Where a worksurface has been retained in its existing form, its retention is based on the fact that it meets the functional requirements of the blocks of instruction where it is used, and that other modules comprising the AIS instructional environment are sufficient to insure the successful presentation of individualized instructional material.

For those situations where there was little or no compelling reason to retain the present work station design, work surfaces of the dimensions shown in Figure 14 are suggested as representing an optimum size for one/two man study, either with a fixed or mobile information display system. These dimensions represent the results of an analysis of the functions and tasks to be performed across the spectrum of the baseline courses and a synthesis of the recommendations available in the human engineering and anthropometric literature (Woodson & Conover, 1964; MIL-STD-1472A, 1969; Dreyfuss, 1960). Construction of these work surfaces can be of any material meeting the requirements of the user; however, specifications for the prototype work surfaces are provided.

Information Display and Presentation

In providing an instructional environment for technical training which is tailored to computer managed, individualized instruction, the

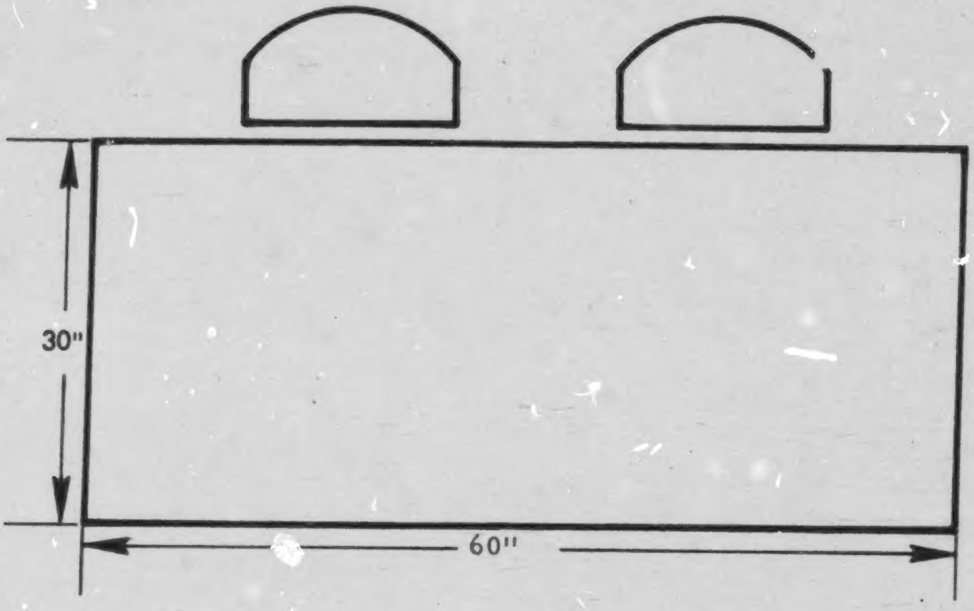


Figure 14. Work surface dimensions

design of the information display module is critical. The information display and presentation module represents not only the instructional focus of the system but is also the most complex and costly module within the system.

The display module of the prototype developed during this study is designed to accommodate presentations on 35mm slides and/or filmstrips, 16mm filmstrips, Super 8mm movie film and audio tape. The information display and presentation module, designated the Audio-Visual Instructional Display System (AIDS), is a device which integrates any two of the above media with an audio tape presentation, and allows for instructor/designer or learner control of the pace of instruction. The AIDS module (Figure 15) is a mobile system which can operate independently of any work surface or structural constraints and is suitable for use in all of the existing physical environments in the baseline courses.

The AIDS module is a two screen projection device with integral tape deck and specially designed control logic. The module can accommodate two projectors - either 35mm slides, 35mm filmstrip, 16mm filmstrip or Super 8mm movie or a combination of these. The module can display two images simultaneously, only one image at a time, or it can hold one image fixed and cause the other to change. Audio portions of the instructional material are presented from the integral cassette tape playback device. The cassette tape also serves as the source of the control pulses which activate the specifically designed AIDS control logic. Controls for the AIDS module are minimal and are located on the display face of the module (Figure 15). Student pacing of his instructional progress is controlled via the responder system or through the (ADVANCE) control on the face of the module. The advantages offered by the AIDS module over existing audio-visual carrel configurations, such as those presented in Figure 16, is that it does not require the student to remain fixed in a single location in order to use the information contained in a particular instructional presentation. Instead, the AIDS module can be used where the information is most appropriate - fixed on a work surface, alongside an existing work station, or alongside a piece of equipment.

Structure Module

In developing a structural concept that would enhance and support individualized instruction in the technical training environment, it became apparent that a single structural arrangement would be an inadequate solution. Conceptually, the structure as a functional element in the instructional environment means that the structure must serve as more than a separator between students. Thus, in the design for an instructional environment for technical training, the structural elements of the system can be configured to meet the functional requirements of each block of instruction.

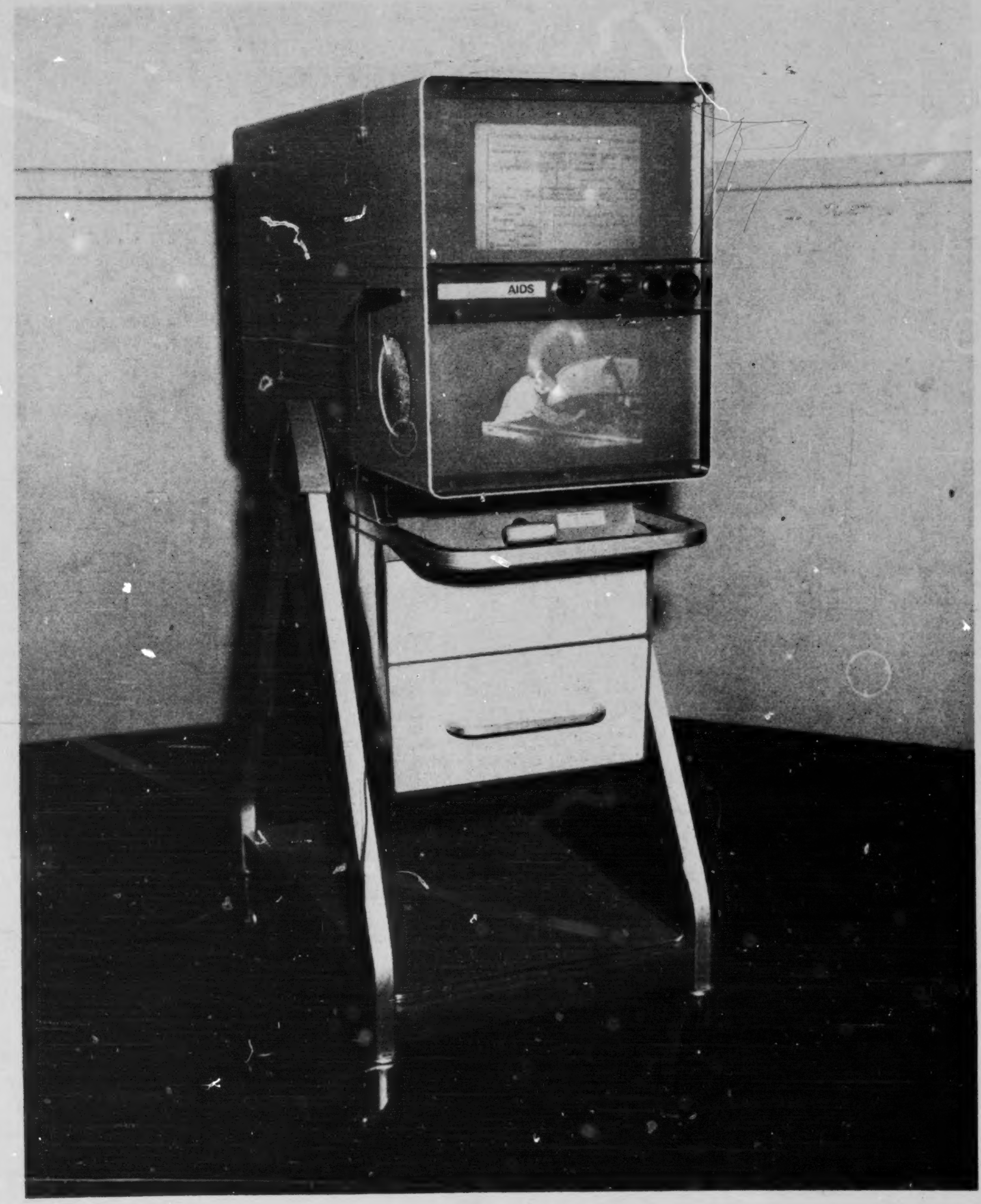


Figure 15. Audio Visual Instructional Display System (AIDS).

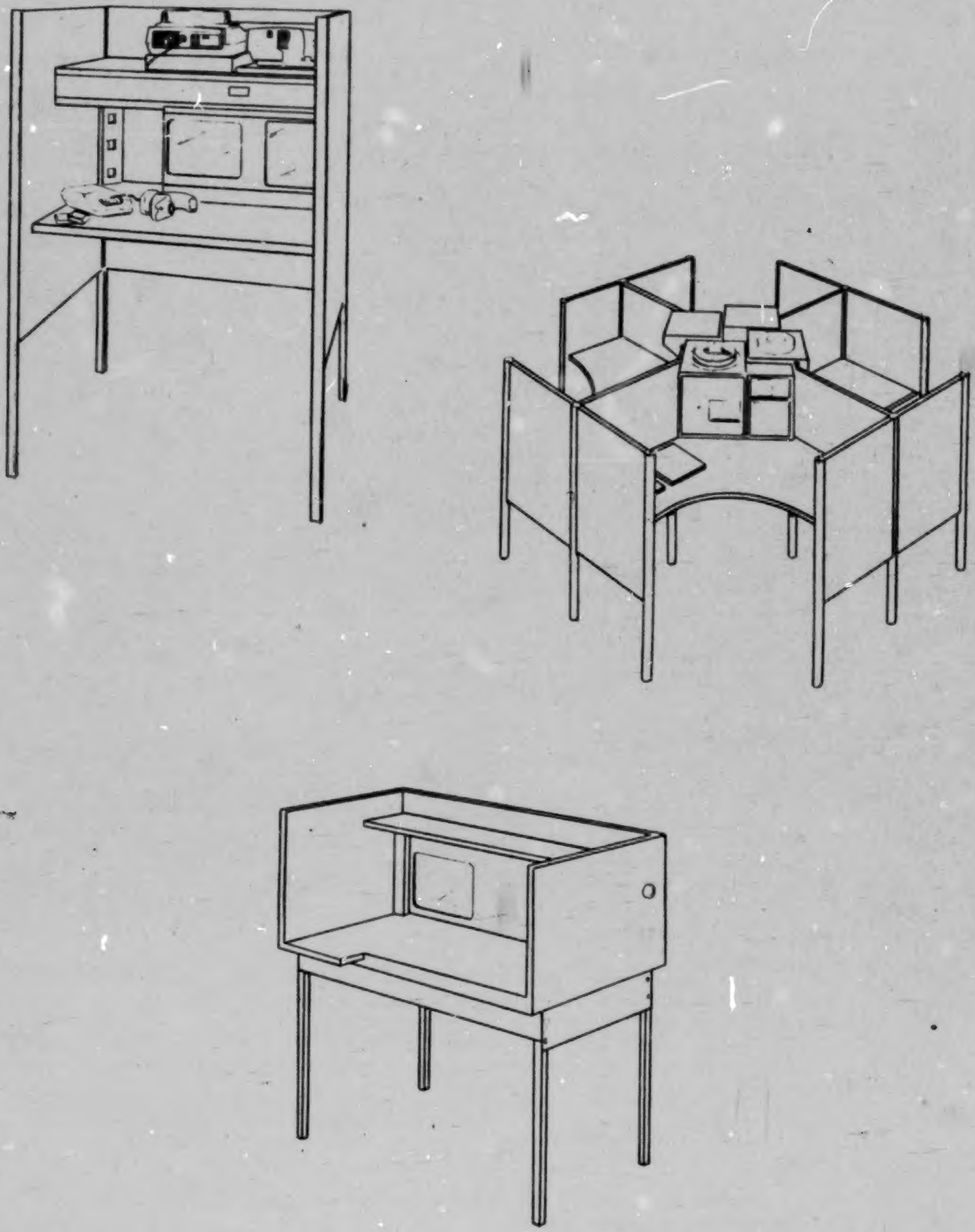


Figure 16. Traditional carrel configurations.

As in the design of the work surfaces for the AIS instructional environment, alternative approaches which are tailored to the functional requirements inherent in each of the baseline courses have been defined. The alternative which has the strongest merit is the "Quad" plan shown in Figure 17. This structural arrangement not only provides for communication between students and between students and instructors, it also provides support for work surfaces, message surfaces (blackboards and tackboards) storage areas and display devices, as well as providing guides and enclosures for required services.

Services

The AIDS module and the structural elements of the basic instructional environment that were designed have been configured to minimize their impact on existing services. The AIDS module operates on 115 VAC and draws only 5 amps. At maximum operating temperature the AIDS module generates 2,048 BTU/Hr. The structural configuration selected for application in any particular area requires no services other than access to existing general service electrical circuits. When and if it is desired to upgrade the AIDS to interface directly with a computer system, then additional cable runs and electrical power may be required, and these too can be integrated into the system.

Work Surface Design

While there are large amounts of anthropometric, industrial engineering, human engineering and architectural data which are peripherally related to the work surface design problem, the specific question of instructional work surface dimensions and configuration have not been systematically treated.

Analysis of work surface design requirements for each of the instructional environments represented in the baseline courses identified 5 discrete worksurface requirements which had to be addressed. These were: (a) single student study, (b) two student team study, (c) two student team practical training, (d) multi-member team study, and (e) multi-member team practical training.

Single Student Study

The worksurface requirement for one individual undergoing an individualized program of instruction using textual and mediated instructional materials is a relatively straight-forward design task. The parameters impacting worksurface configuration are basic to all worksurface design problems. They are: (a) worksurface depth, (b) worksurface length, (c) "work vector," work vector is defined as the user's angular relationship to a particular workstation or display (Propst, 1968), and (d) load bearing capability.

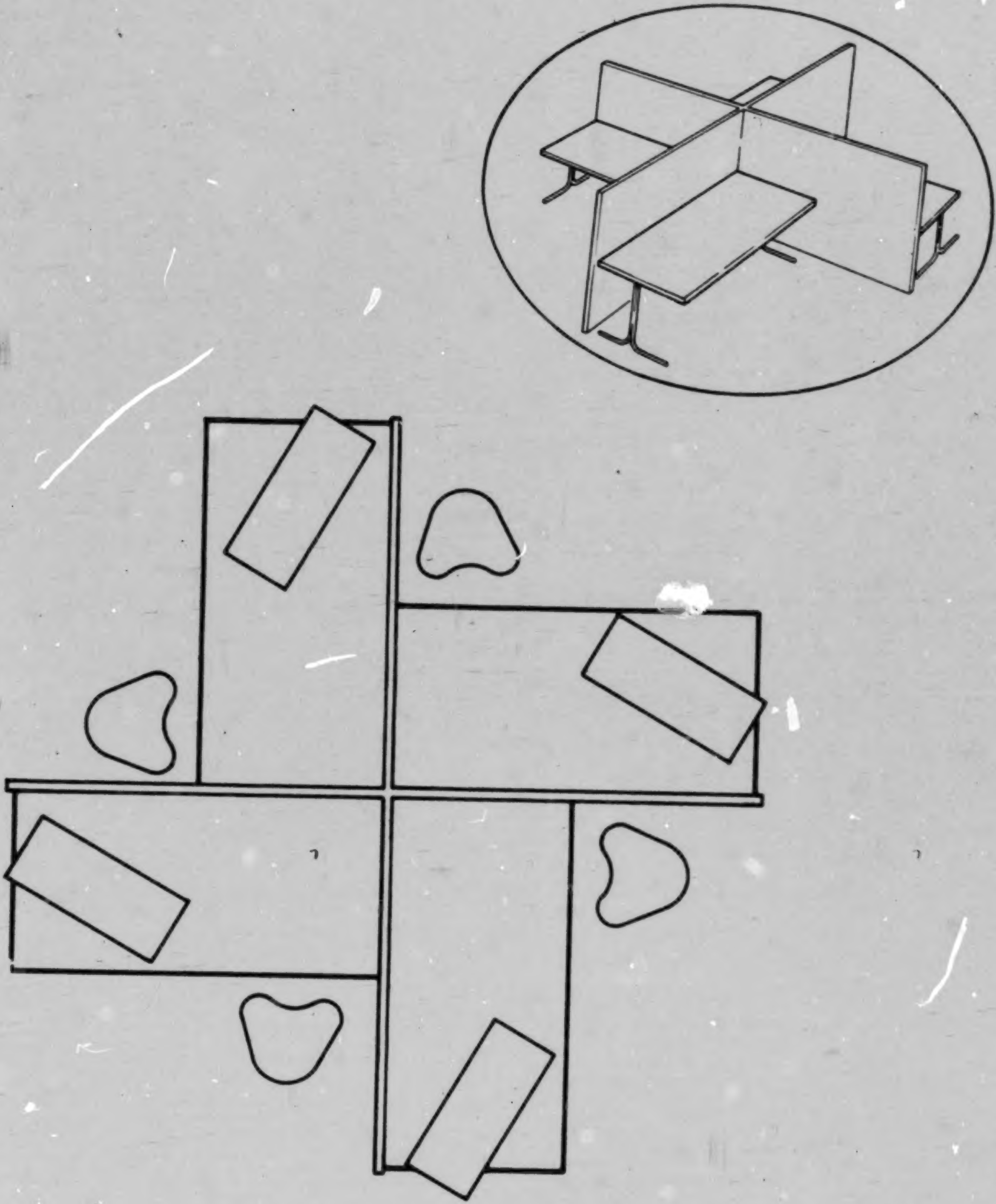


Figure 17. Quad structural arrangement.

In the case of the single student, a worksurface configuration is derivable from the available anthropometric and industrial engineering data (Woodson & Conover, 1964); which provides an empirical basis for establishing desirable minimums for worksurface depth, length and vector. These minimums:

depth = 16"

length = 24"

work vector = 0° optimal

have been exceeded in the alternative single student configurations developed during this program. The alternate configurations considered are shown in Figure 18; each of these configurations satisfies the dimensional requirements for a single study station and more closely approximates the optimal work area dimensions identified by Grandjean (1969), than the minimums identified above.

Specific applications for these work surface configurations are directly dependent on the commitment to individualized instruction and the functional characteristics of the instructional activities to be performed. In the weapons mechanic course for example, there are several blocks of instruction at the beginning of the course which deal with introductory electronics, career field information, security, etc., which can be provided to the student as individually paced presentations. Similar blocks of instruction occur in the first half of the PME course; while almost the entire inventory management course can be presented in this manner. Selection of a worksurface configuration to satisfy the functional requirements in these situations is more a matter of establishing class densities and determining optimal carrel system configurations within the spatial and dimensional constraints imposed by representative classroom sizes. While any of the workspace configurations shown in Figure 18 could be used to satisfy the instructional requirements described above, the recommended configuration is the rectangular design shown in Figure 19. This configuration is dimensionally adequate for the required tasks and is the most flexible configuration with respect to alternative spatial layouts and structural configurations. Depending on the sturctural system selected, this configuration will also satisfy the requirements for a worksurface to serve two man teams during the introductory stages of learning in advanced blocks of the PME and weapons mechanic courses.

Practical Training

The requirements and constraints influencing the design of worksurfaces for practical training are substantially different between the PME and weapons mechanic courses. In the PME course, two man teams or individual

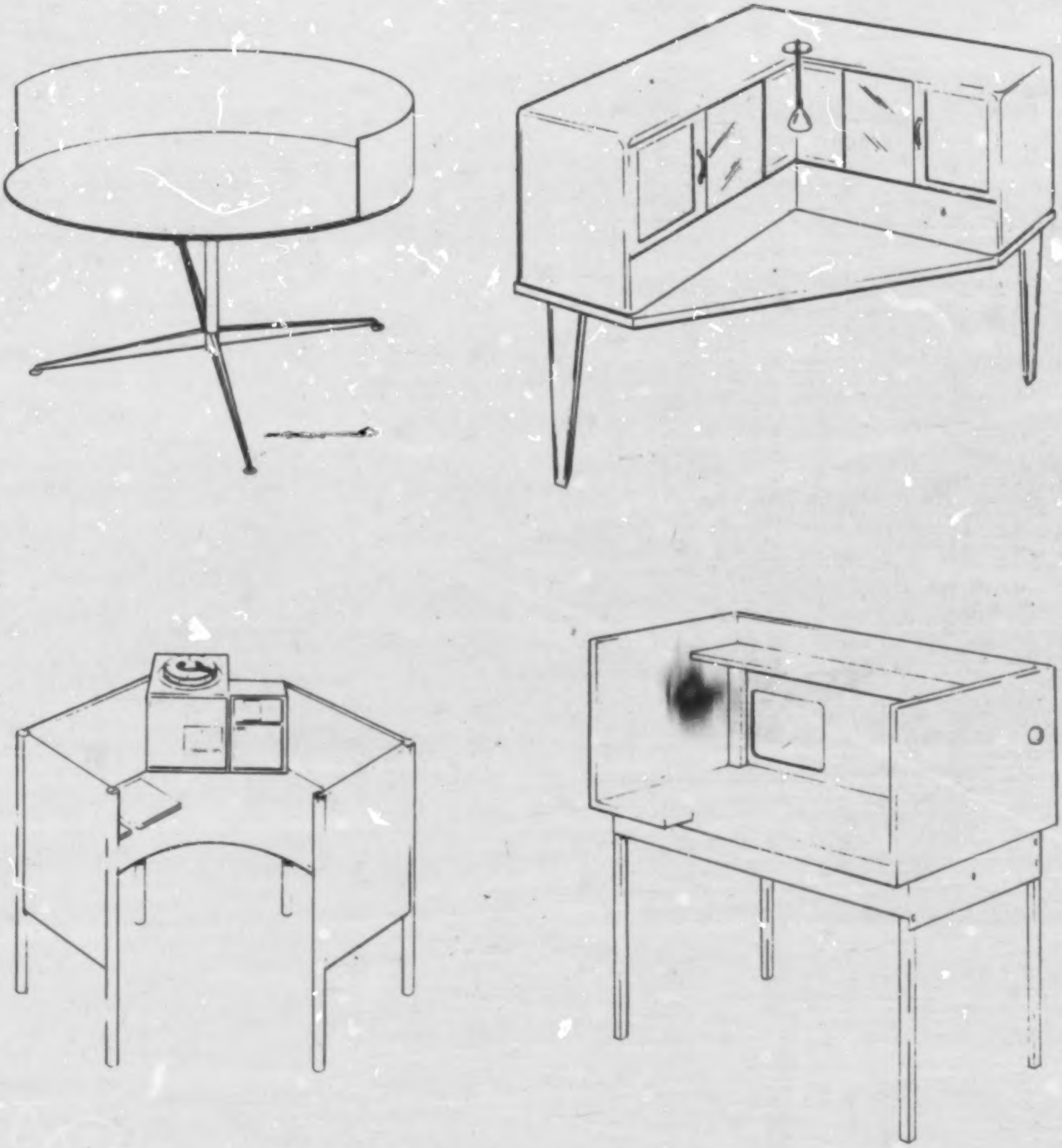


Figure 18. Alternative workspace configuration.

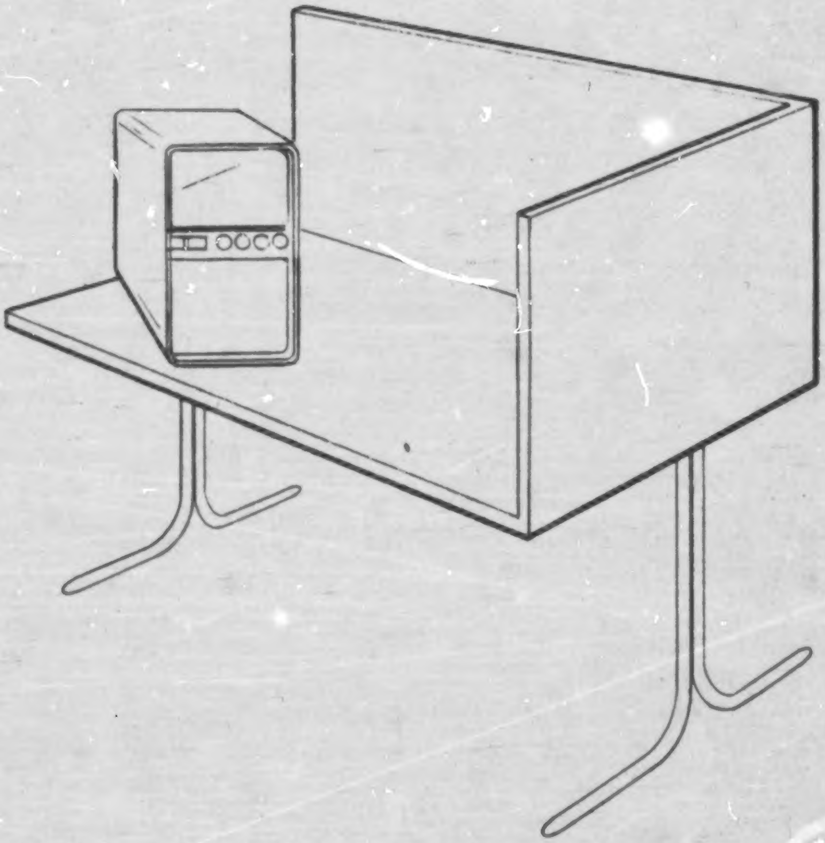


Figure 19. Study carrel configuration.

students working with test equipment and calibration sources of varying levels of sophistication actually perform calibration on an extremely wide range of equipment. The primary worksurface constraint operating in this environment is space; whatever the worksurface configuration selected for this environment it must be large enough to include the combination of equipment undergoing calibration, signal sources and test and measurement equipment. After reviewing the types of actions performed in the calibration of equipment, frequency of use of different types of equipment, and the functional relationship between equipment, it became evident that little or nothing could be gained by modifying the existing worksurface used in the practical portions of the PME course.

In the weapons mechanic course, Blocks III, IV, and V are blocks of instruction dealing with familiarization, identification, assembly, disassembly and repair of munitions and guns. Each of these blocks of instruction requires that the student have available to him a surface that will support large, bulky and heavy objects and that he have access to all sides of the objects with which he is working. This requirement for 360 degree accessibility combined with the length and weight of certain of the weapons requires that the worksurface be free of fixed components and be substantial. The present workbenches used in these blocks of instruction satisfy these functional requirements, but they lack two elements that seem required for effective individualized instruction - privacy and provisions for the presentation of instructional information.

Audio-Visual Instructional Display System

In designing an information presentation and display system for individualized instruction, the advantages - economic, logistical, and production - accruing to the use of film based systems quickly become apparent. These advantages, plus the requirement for individual pacing at diverse locations, quickly eliminated the possibility of using any centrally based distributive systems such as broadcast TV or dial access. As has been pointed out in this report, the media selected as being most effective for the technical training applications under consideration were 35mm slide 35mm filmstrip 16mm filmstrip, Super 8mm film and audio tape. The packaging of these formats and media into a presentation system consistent with the instructional requirements and environmental constraints imposed by class size, space availability, etc., represented a challenging design problem which was not resolvable through the purchase of available off-the-shelf hardware.

An initial assumption in the design of a presentation module for the instructional carrel system was the development of a presentation design or designs that would be generalizable across the largest number of instructional situations and environments. This assumption was predicated on minimizing the amount of training in the use of instructional hardware and in reducing the procurement and operating costs associated with acquiring and maintaining a large inventory of different audio/visual equipment. In light of this assumption, the presentation module selected or developed for application to the carrel system had to achieve certain functional goals. The module had to:

1. Contain all projection device(s) and projection surfaces.

2. Contain the audio and control signal sources.

3. Function under normal ambient lighting and under ambient noise conditions.

4. Provide for easily learned operation and easy maintenance.

A further assumption was made, that a desirable characteristic for the module would be to have the module itself configured in such a manner that it would be equally useful in the study, and practical training environments.

Working with these assumptions, the selected media and the present state-of-the-art of film projection, tape transport and media control systems, the configuration described below was developed as a solution to the instructional information display and presentation system design problem.

Functional Description

The audio-visual instructional display system (AIDS) module (Figure 20) is a presentation device designed for the simultaneous or sequential presentation of imagery from two projectors located within the module.

These visual presentations are supported by a synchronized audio presentation produced by a cassette playback device integral to the module. The cassette playback device also serves as the source of signals controlling the pacing, sequence, and synchronization of module operation. The module was designed for operation with minimal training, and with particular attention to the human engineering and maintainability parameters which affect the acceptability of the system to both students and instructional systems personnel.

Access to the projection devices, for loading and unloading film presentation, is through generous ports on the left side of the device. All student controls are located on the front panel; while access to the tape transport is at the rear of the unit. For maintenance operations, the rear panel of the device is removable (Figure 21) providing access to 85% of the modules component parts; access to the remaining 15% is possible by removing the upper screen at the front of the module.

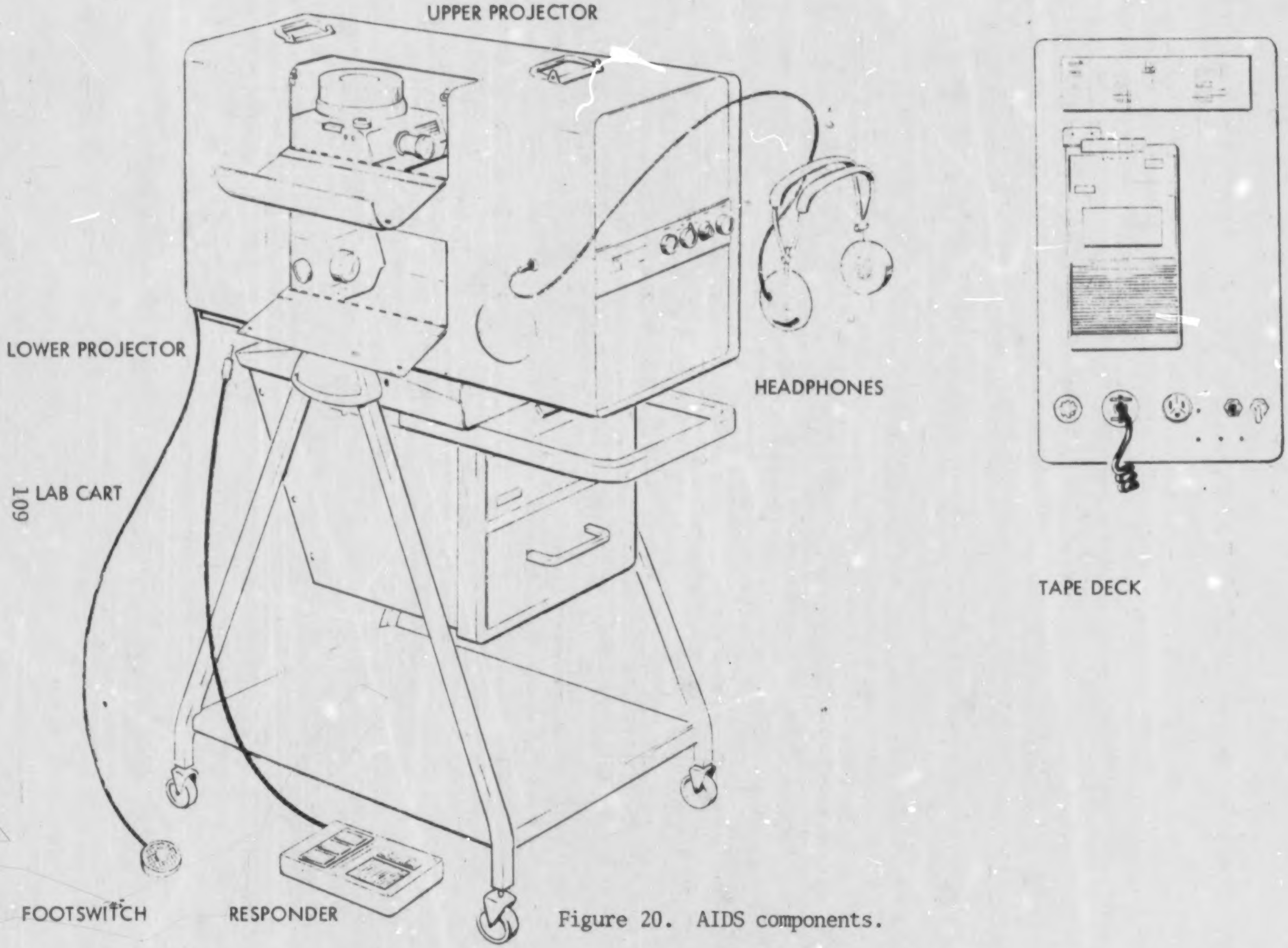

UPPER PROJECTOR
HEADPHONES
LOWER PROJECTOR
LAB CART
TAPE DECK
FOOTSWITCH
RESPONDER

Figure 20. AIDS components.

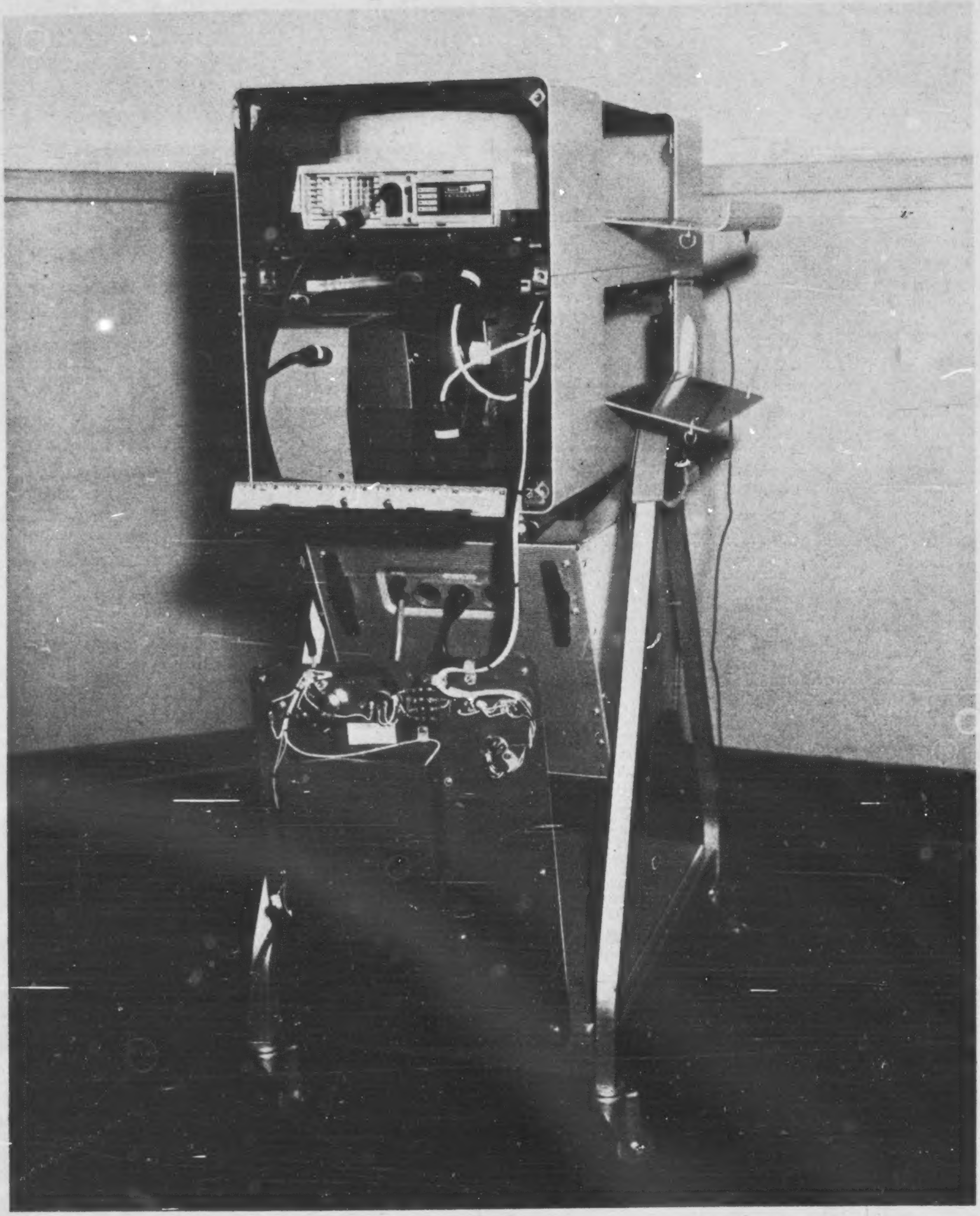


Figure 21. Access to module

The module is designed to operate in the following manner:

1. User opens access doors and inserts film cartridge or slide trays into their respective projectors. If the presentation involves synchronized projector operations or an audio presentation a cassette is inserted in the cassette transport.

2. User activates the unit by setting the "POWER" switch to "ON."

3. The user selects the mode of operation he desires: SOUND ONLY, LOWER (lower image area only), UPPER (upper image area only), BOTH (upper and lower image areas).

4. Using the ADVANCE control the user advances each projector to the focus frame and manually focuses each projector.

5. User sets the tape transport to "PLAY" and closes all access doors.

6. User places headphones in position and adjusts VOLUME control to desired level.

7. The tape cassette provides audio information synchronized to the visual presented by the module; a separate track on the tape provides cue signals that control operation. These signals control the following functions: (a) upper projection advance, (b) lower projector advance, and (c) tape transport stop. The signals may occur at any point in the presentation and in any sequence that the software designer wishes.

8. Upon receipt of a stop cue, the tape transport will stop and will not restart until the ADVANCE control, footswitch or responder are activated by the user; i.e., the tape will stop and images will be held until the user restarts the system.

9. At the end of a particular lesson or block of instruction, the user would open the access doors, stop the tape transport, remove the cassette, rewind (if required) each film presentation and remove the cartridges or slide trays.

Specific variations of this operational sequence are possible because of specific projection system differences or to allow for specific software variations. Under most circumstances in the baseline courses, this would be the mode of operation for the module.

The controls on the face of Audio-visual Instructional Display System (Figure 22) have the following fuctions:

POWER - This 2 position switch controls power to all elements within the AIDS.

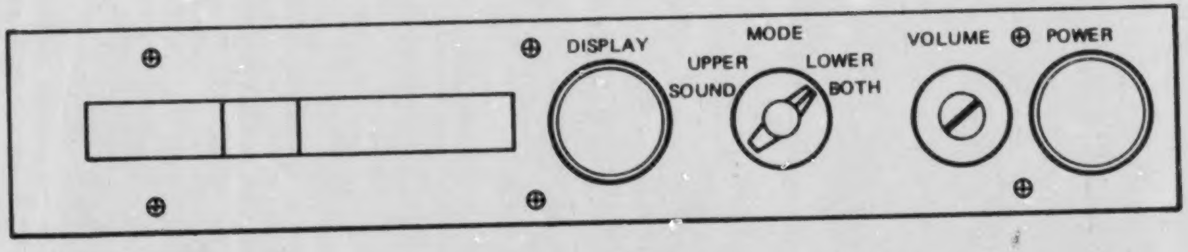

DISPLAY
MODE
UPPER
LOWER
SOUND
BOTH
VOLUME
POWER

Figure 22. AIDS controls.

ADVANCE - Activation of this pushbutton control will cause the following to occur: (a) If the tape deck is switched into the system, use of the ADVANCE control will cause the tape deck to run. (b) If the tape deck is not switched into the system, use of the ADVANCE control will cause the selected projector(s) to advance one frame.

MODE - The mode select switch allows the user to select those functions of the AID system he wishes to use. The functions which can be selected are:

SOUND - In this position, only the tape deck will be operating, providing audio output to the headphone jacks.

UPPER - In this position power is switched to the tape deck and the upper projector only. In this position the upper screen would be in use and only those control signals intended for the upper projector would be recognized.

LOWER - In this position power is switched to the tape deck and the lower projector only. In this position the lower screen would be in use and only those control signals intended for the lower projector would be recognized.

BOTH - In this position power is switched to the tape deck and both projectors. Both screens would be in use and control signals for both projectors would be recognized.

VOLUME - This control allows adjustment of audio volume at the headphone jacks.

Structural Description

The Audio-Visual Instructional Display System is a 14 inch (W) 36 inch (L) by 16 inch (H) enclosure for the selected projection devices, their display surfaces, tape transport, signal processing logic and associated cabling and structural supports. The AIDS is constructed of aluminum alloy sheet formed as an open ended tube. Internally, the tube is fitted with teflon guides for mounting of projector systems in consistent and precise alignment. Precise positioning of a given projector system is accomplished by attaching to each projector a specially tailored mounting plate which when placed in the guides positions the projector horizontally, vertically, and at a precise distance from the projector screen.

Projection devices selected for use in the AIDS module are commercially available products of proven quality and reliability. Once particular formats were selected as the presentation formats to be incorporated in the module, the selection of particular projection systems could proceed on the basis of empirical data with respect to operating experience, reliability, durability, ease of use and compatibility with other audio-visual devices presently in use or projected for other applications. Analysis of the available projection devices and film handling systems led to the selection of the following devices as representing the capabilities and characteristics considered to be most desirable in this instructional context:

1. 35mm slide. Kodak Ektagraphic series slide projectors,
2. 35mm filmstrip. Bell and Howell 745 series filmstrip projectors,
3. 16mm filmstrip. Audiscan 2000 series filmstrip projector, and
4. Super 8mm film. Kodak Supermatic 60 or Technicolor Model 1000 series projectors.

Available projection systems were selected to avoid the problems and costs associated with the development of special purpose projection systems.

The audio portion of the AIDS is based upon a cassette tape transport mechanism and sound amplification system feeding the headphone jacks of the module. Audio portions of instructional material are recorded on Track 1 of a dual track tape; Track 2 is reserved for control signals. While any reliable dual track transport system would satisfy system requirements, two systems warrant special mention. The first of these is the system used to mechanize the prototype developed during this program. This cassette tape recorder was a Sony, Model TC-124 tape recorder modified to a dual track configuration using a Nortronics W2RGF-A half track dual channel head assembly. While selected primarily for its availability, size, and reliability, the unit also provided simple control operation and an acceptable signal to noise ratio. The second system warranting special mention, because of its application to later versions of this module, is a playback only cassette transport based on the 3-M Corporation's Bi-Peripheral drive system. The features, capabilities and economics associated with this approach to the audio portion of the prototype were evolved too late in this program to be included. However, it appears to be an extremely interesting alternative to the approach actually implemented. Selection of this type of transport mechanism fitted with a dual track head would allow the cassette mechanism to become an integral part of the module structure as shown in Figure 23.

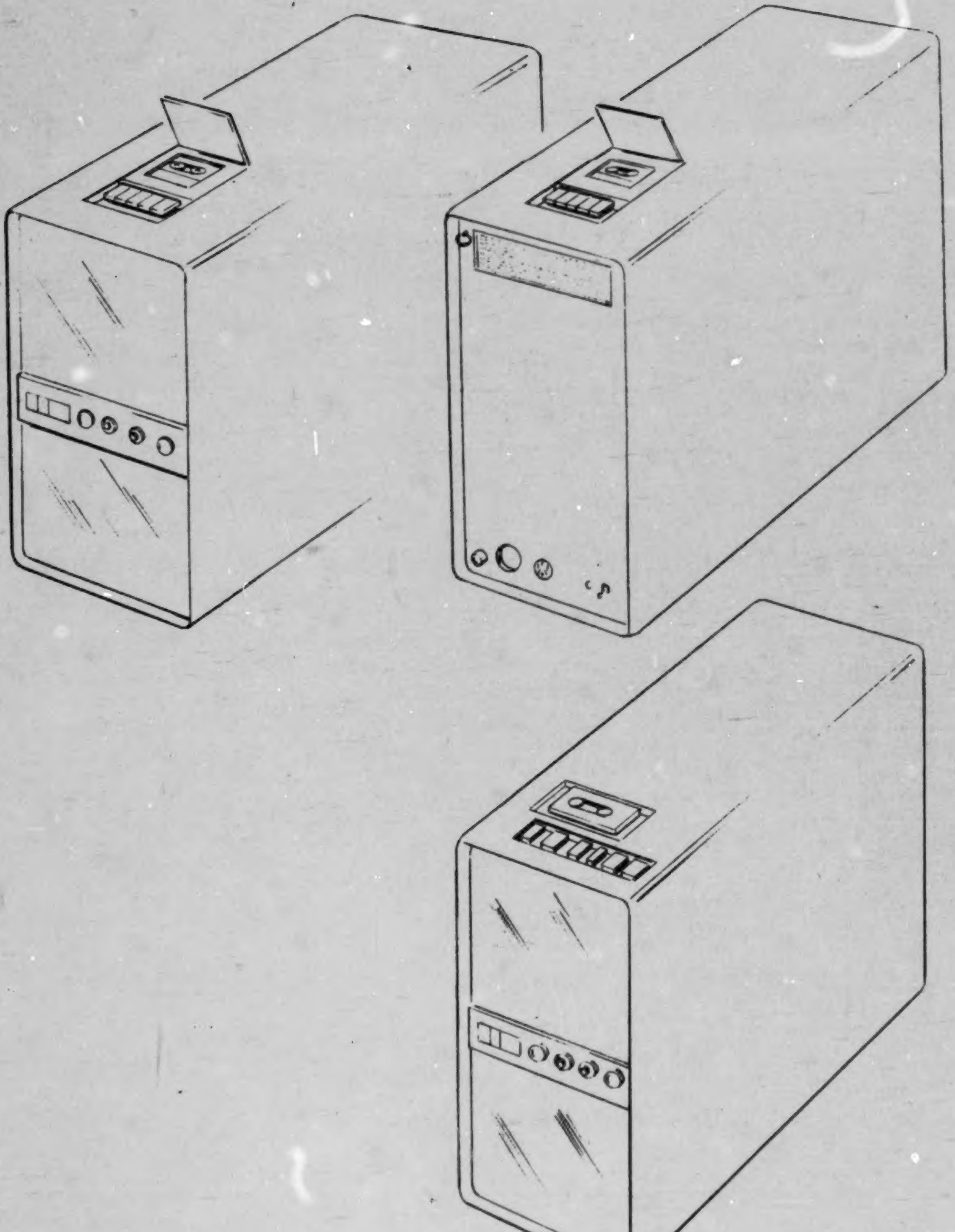


Figure 23. Alternative audio component configurations.

Control signals which are used to advance each projector and to cause the tape to stop (thus causing the presentation to hold at a given point) are recorded on Track 2 of the cassette tape. These signals are tone pulses of specified frequency and duration which are read by the tape unit head assembly and routed to the tone processing circuits built into the module. Control frequencies, pulse duration and amplitude were developed in accordance with the proposed American National Standards Institute (ANSI) standard ANSI PH 7.4 "Draft Proposed American National Standard for Audio-Visual and Educational Use of Co-Planar Magnetic Cartridge Type CPII (Compact Cassettes)." This standard establishes, with industry backing, that one preferred system for audio-visual synchronization is one in which control signals are recorded on a separate track from the audio. Control signal frequencies identified in the standard for specific functions are 1,000 Hz for projector advance and 150 Hz for program stop and correct answer coding; these have been incorporated in our design. The ANSI standard identified optional frequencies available for use as being 400 and 2300 Hz. Since the AIDS requires at least three discrete control signals for effective operation, 2300 Hz was selected as an additional control signal to be incorporated in the module. These signal frequencies are placed on the tape at the required points in the instructional flow and, when detected by the decoder circuitry in the module, cause the simultaneous or sequential activation (or deactivation in the case of the 150 Hz tape stop pulse) of the tape transport and both projector systems.

The optical portion of the AIDS was designed to be as simple, maintenance free and rugged as possible. To avoid the problems associated with mirror alignment, mounting, and the cost associated with such an optical system, a straight-through rear projection system was selected and developed. The selected system employs a straight optical path from the film plane of the selected projector to the rear surface of the projection screen. While this approach is appealing because of its lack of special components and supporting structure, it does possess certain disadvantages. These are the requirement for a short focal-length lens and the overall length of the module (this is dictated by the minimum projector to screen distance required to achieve a desired image size). The optical system in the AIDS produces a 9 inch (W) by 6 inch (H) image using 35mm slides and a 7.5 inch (W) by 5.5 inch (H) image using 35mm filmstrip. These images are projected by 2 inch and 1.5 inch focal length lens, respectively, onto a rear projection screen with the following characteristics: (a) substrate - clear, rigid acrylic plastic, (b) thickness - 1/8", (c) color - neutral grey, (d) resolution - 64 lines per millimeter, (e) gain - 3.0, and (f) falloff - 65 percent (measured at 30° off axis).

In order for imagery projected on the rear projection screens of the module to be viewed without reversal, all imagery must be reversed prior to projection. In the formats selected for implementation here this does not pose any significant problem; 35mm slides, 35 and 16mm filmstrips are simply reversed in their respective trays and cartridges during packaging. Super 8mm movie film poses a somewhat more difficult problem in that it must be printed on B wound film during processing and then rewound and projected as A wound film.

While the optical system used in the prototype module is adequate for the purposes of this study (i.e., the optical system and the module demonstrate the concept and the role of multi-media presentation systems in a program of individualized instruction), the large scale implementation of such a system should involve refinement of the optical system to preclude the requirement for special focal length lens and the reversal of imagery.

The AIDS is designed to be mounted at one end of the horizontal worksurface in a given instructional carrel. In those environments and blocks of instruction corresponding most closely to conventional forms of academic instruction, an arrangement as shown in Figure 24 is an acceptable viewing and working arrangement. To provide an alternative to the fixed-base instructional environment, the AIDS is designed to mount on most conventional laboratory equipment carts. This relatively simple design change provides the capability to display information and instructional materials within the context of the tasks to be performed. Thus, in the PME course during the practical training blocks, the student can have available to him at the worksurface - all required instructional material. The same would be true in the weapons mechanic course.

By freeing the AIDS from the worksurface and structural components of the instructional environment we have, in effect, expanded the instructional environment from a single desk space to the point where it now encompasses almost the entire functional environment within which students in Air Force technical training perform. The AIDS concept allows individualized instruction and/or two man team instruction to be provided in just about any location associated with the baseline technical training courses.

Instructional Carrel System Structural Configurations

In the previous pages the requirements and proposed solutions to the design of worksurface and information presentation and display modules for individualized technical training was discussed. In the following paragraphs, alternative solutions to the problem of providing a structure where individualized technical training can occur are presented.

The structural module for individualized training can be as simple as an ordinary table or as complex as one of the "total sensory environments" propounded by McLuhan and others; it can be a desk in an overcrowded city school or a soundproof, air-conditioned, sterophonic, upholstered, audiovisual womb as proposed in some science-fiction novel. In the context of

Air Force technical training, it is the means whereby the modules which comprise an instructional environment are tied together both physically and conceptually to form a physical site within/about which instruction occurs.

The factors to be considered in the design of the structural module are technological, physical, aesthetic, and psychological. The technological factors to be considered in the design of any study space structure, but particularly in the case of instructional carrels, include the latest in materials technology (what should the structure be made of), fastening technology, (how should the structure be held together), acoustical engineering (does the structure need to be designed to contain or restrict local or ambient noise levels), general mechanical design (how are services routed to and through the instructional environment), and air conditioning and ventilation (is cooling or air circulation a problem).

The physical factors influencing design of the structural module are somewhat contingent on the technological solutions selected and are usually considered simultaneously. These factors include floor loading, floor and vertical space requirements, number of carrels vs available space, requirements for weight bearing horizontal and vertical structures, and how these can be accommodated.

Aesthetic factors enter the design problem of individual study environments not as simple "window dressing," but rather from the standpoint that the student will spend a large percentage of his time in the confines of this environment, and his comfort and subjective reactions are critical to his acceptance and ultimately to his learning performance. Particular aesthetic factors entering into the acceptance of individual study environments are the overall color scheme, lighting selection and design, and the flexibility of the environment with respect to individual differences.

The psychological factors requiring consideration range from relatively firm, empirically determined data about man's physiological capabilities to softer, more intuitive concepts of personal space and organizational psychology. Such factors as sightlines, optimal viewing areas, anthropometrically and kinesthetically arranged and located, working and resting postures and optimal work vectors are examples of those relatively "hard" aspects of human behavior that can be identified as influencing training environment design. Less easily defined are such factors as: under what conditions does an individual feel confined or exposed or just cramped; what constitutes an optimum arrangement of individual spaces to reduce/increase communication and interaction between students; should the instructor be visible and accessible at all times or should he be located away from the study areas; etc. Another factor which is extremely critical is the effect of subjective time on student learning performance.

Student involvement and interest in the subject matter is both determined by, and highly determinant of, the optimal length of lessons, mediated presentation and sequences of instruction. Thus in each environment there is a requirement to determine an optimal sequence of instruction and media usage and relate this to the design requirements and characteristics of the structural module.

Recognizing that all of these factors interact to determine what constitutes an optimum structural configuration for individualized technical training, it is not surprising that there are a large number of solutions that have been proposed for this problem. The NAVA directory for 1972 (NAVA, 1972) alone, lists twenty individual manufacturers of study carrels. There are at least ten other organizations marketing structures designed to accommodate individual study, and this number does not include the host of office equipment and industrial laboratory equipment manufacturers whose products would be easily convertible into study and practical training structures and enclosures. In attempting to apply some logic to the design and/or selection of a structural system for individualized technical training, it was quickly apparent that negative criteria could be formulated rapidly and those designs which were not applicable to our purposes could be identified and eliminated. Establishing criteria to distinguish between superior and marginal alternatives was a much more difficult task, particularly with respect to selecting a design or approach which could be applied to more than a single environment.

In considering individual work spaces a classification scheme has evolved which identifies study spaces as being one of three types:

> The "dry" station - similar to the usual student desk, library table, etc., basically a worksurface with some supporting and perhaps enclosing structure. Dry stations have no electrical services except for lighting.
>
> The "wet" station - a space or carrel able to accommodate and provide service connections to any of several information presentations systems.
>
> The special purpose station - a space or carrel designed to provide information or learning experiences in a very specialized form (e.g. a CAI terminal).

The configurations that these individual student carrels and carrel groupings have taken are partially determined by instructional functions and partially by economic factors operating upon the fabrication and distribution of individually tailored study environments. It was only with the inception of this study that a rational, systematic analysis of the requirements for individual work environments has been performed.

The difficulty encountered in establishing a rationale to support selection of a single approach or design, reinforced our original assumption that the solution to the problem was not a single example of existing educational or library furniture but rather a system of components that could be tailored to the specific requirements of various training environments.

Acceptance of this general approach to problem solution allowed consideration of several different designs for complete carrels and carrel structures as equally useful and to develop the following set of designs as a good mix from which specific solutions could be selected.

It is important that distinctions between the instructional function of specific carrels or classes of carrels be made and considered in the design and/or selection of an instructional carrel system. Generally speaking, carrels, both by definition and by utilization, have been intended to service the requirements inherent to acquiring academic skills and knowledge; thus, carrels have primarily been conceived of as being individual study space. Whether used as the primary, secondary, or as the remedial source of instruction, little thought has been given to whether these academic activities require specially configured environments.

One of the primary hypotheses underlying this study has been that different levels of instruction, and most particularly different types of training require different instructional environments. Analysis has shown that the requirements imposed by different facets of the training problem dictate the configuration and content of the modules which comprise the instructional environment. Specific to the structural module are several distinct aspects of technical training which require structural modifications or changes. Academic carrels as they have been developed are not designed to facilitate interaction between students. In fact, they are specifically designed to preclude or reduce interaction. In technical training there are specific requirements for interaction between team members in a variety of technical specialities. In order to satisfy these requirements, normal structural systems and work surface configurations need to be altered. Design V (described on the following pages) is intended to enhance interaction between team members. Academic carrels as presently developed, are not adequate in size or design to absorb the requirements inherent to hands-on training in the electronic or mechanical specialty areas. Designs I, II, V and VII are designed specifically for the requirements imposed by hands-on training. Academic carrels as presently executed represent fixed bases from which information may be gathered; only AIDS or the stand-alone devices allow instructional media to enter the hands-on work area itself.

In the following paragraphs, a series of structural concepts are developed and presented as a mix of alternatives from which specific solutions can be matched against the detailed requirements of individual blocks of instruction.

Design I

This configuration (see Figure 24a) is based on a simple 5 foot by 2 1/2 foot worksurface. It is for all intents a sturdy table with privacy and spatial control provided by free standing 4 foot high partitions on 1, 2 or 3 sides (depending on the number of carrels to be associated in a given space). It was designed as a flexible low cost, generalizable structure and worksurface system capable of accommodating several different types of information display and presentation systems. A representative configuration for such an application is shown in Figure 24b.

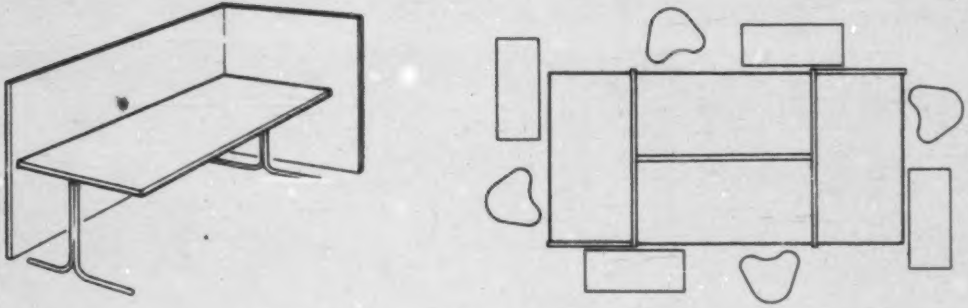
Design II

This configuration (see Figure 24c), developed by T. Jouhlson of Hughes Aircraft Corporation, designated the MOD-QUAD system, is a structure designed to accommodate 3 or 4 individual study positions in a common structure. This design approach, based on commercially available 4 ft. (H) by 5 ft. (L) panels, can be used in conjunction with the table structure from Design I or with integral worksurfaces. This structural design is equally adaptable to worksurface mounted or free-standing presentation and display devices. The design is particularly notable with respect to its ability to serve the requirements implicit in the transition from group paced to individually oriented instruction. The orientation of individual positions and the height of the partitions between students is such that from any student position the instructor at the front of a room can be observed and heard. Direction of students attention to materials on his individual worksurface or to display equipment on his worksurface brings the focus of attention within the individual study area and the structure is so designed as to provide privacy for the student without completely negating student interaction.

This structural concept is further distinguished by its aesthetic and utilitarian treatment of worksurface attachment, panel connection, and services routing. The panels are attached via large hinges which interconnect in such a way as to provide an obstruction free space at the intersection of the panels. Services from either under the floor or dropped from the ceiling sources can be contained in this intersection space and routed unobtrusively below the worksurface to connectors and specific equipment.

Design III

This design (see Figure 25a) developed by the Training Aids Branch, Lowry Technical Training Center, is designed as a study area for 1 individual. This configuration is capable of supporting dual screen presentations with synchronized audio. Assembly of 4 Design III modules into a cluster represents a very effective method of space utilization. However, the design does produce a more isolated effect than Design II.

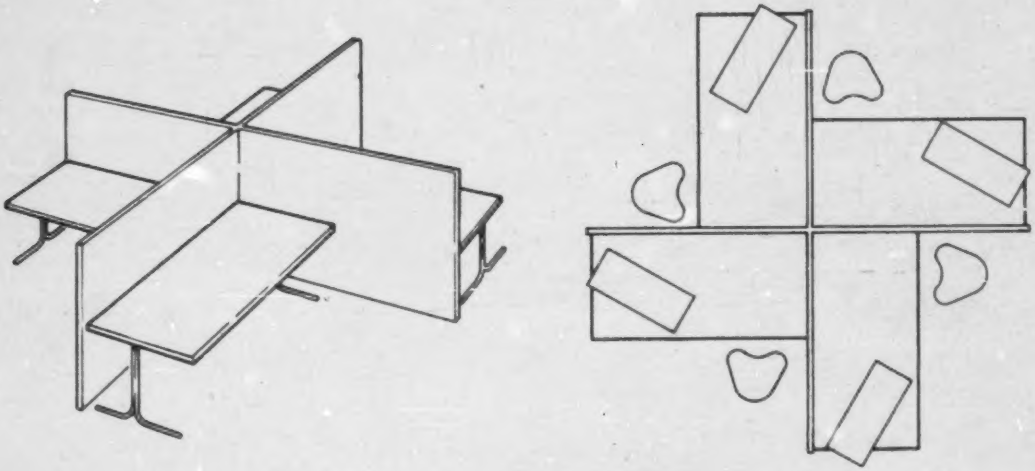


DESIGN i

(a)

DESIGN I ROOM CONFIGURATION

(b)



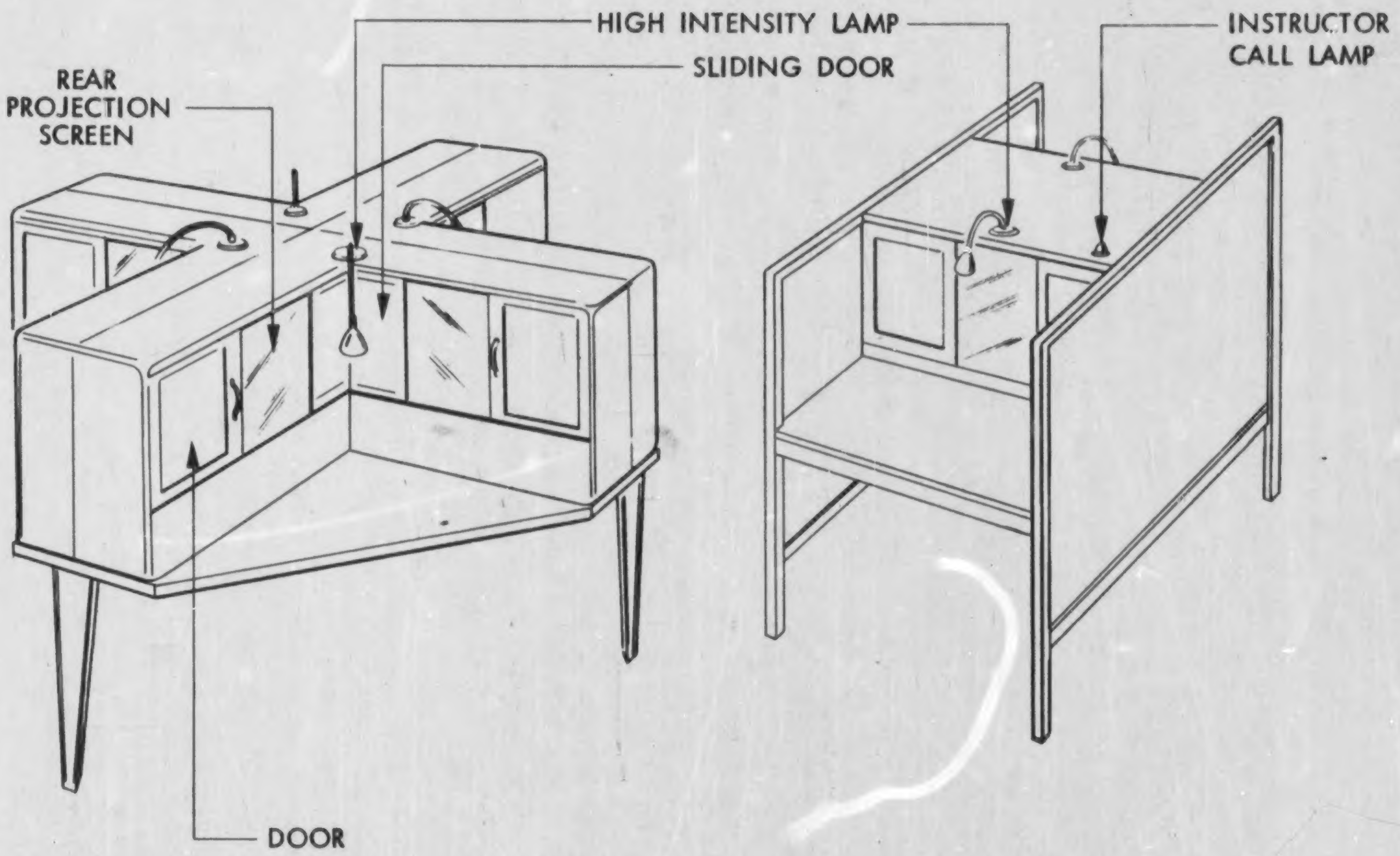
DESIGN Ii

(c)

DESIGN II ROOM CONFIGURATION

(d)

Figure 24. Alternative carrel structure configurations.


HIGH INTENSITY LAMP
SLIDING DOOR
INSTRUCTOR CALL LAMP
REAR PROJECTION SCREEN
DOOR

(a)

DESIGN III

(b)

DESIGN IV

Figure 25. Design III/Design IV.

Design IV

This design, shown in Figure 25b, is the second in the series developed by Lowry Training Aids. In appearance and structure it is two conventional rectangular carrels fabricated as an integral unit; however, its internal construction makes it much more than that. Utilizing a beam-splitter, presentations displayed on one side are shown simultaneously on the other as well. The primary role for this design is in the development of instructional materials. The instructional developer may observe and measure student reaction to instructional packages, alternative strategies or even individual frames while observing the same materials himself. As a device for testing materials, the instructor can monitor the material being presented to the student and pose questions which build upon and adapt to the students preceding responses.

Design V

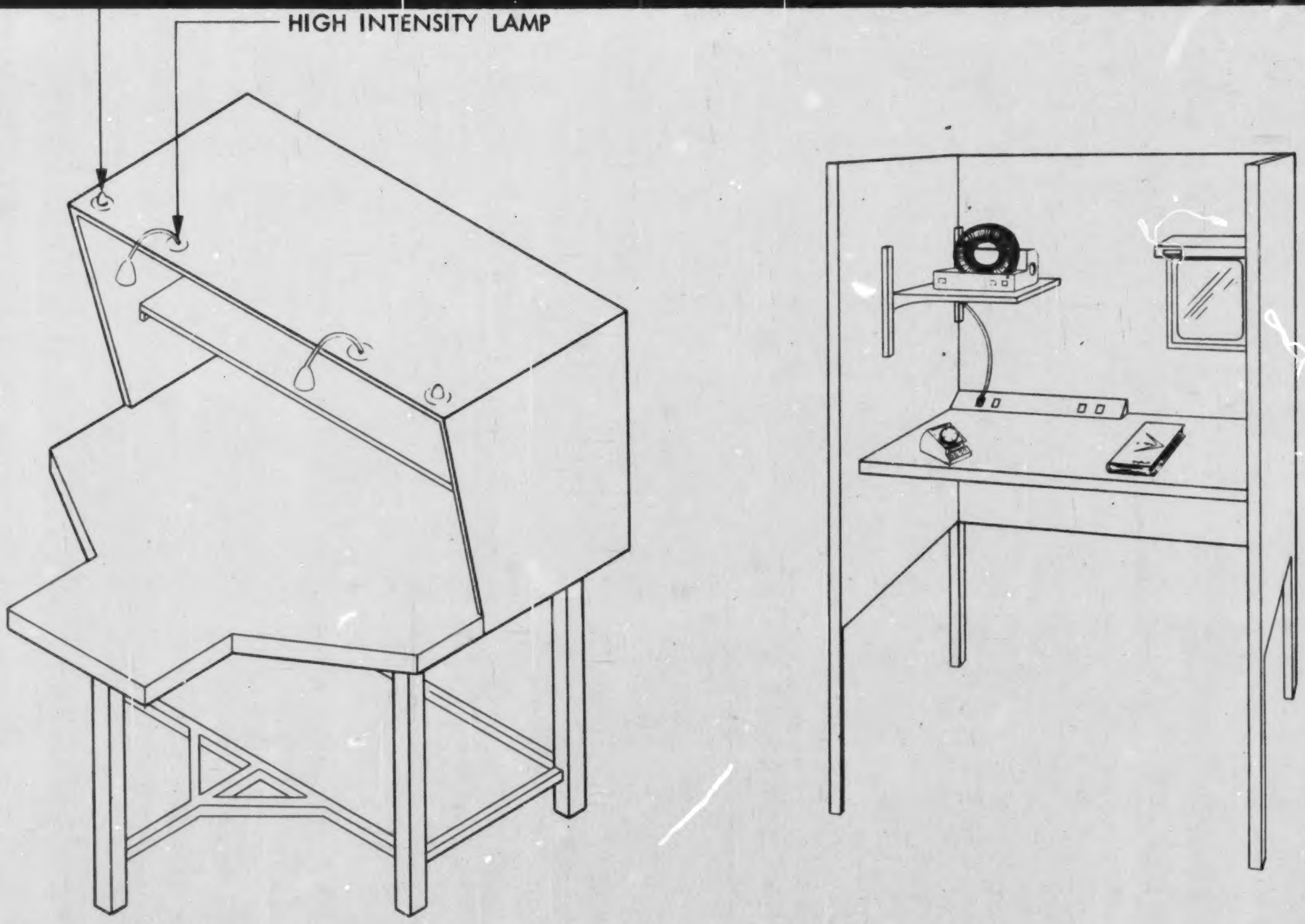
This carrel (Figure 26a), another in the ATC series developed at Lowry, is unique in several of its features. The most prominent of these is that this carrel is designed specifically to enhance the interaction between members of a two-man team. This design has positioned two students in such a way as to allow communication between the two while maintaining adequate worksurface space and viewing angles for each student. It is also intended to serve for remedial situations.

Design VI

Design VI is a variation on what has come to be a more less standardized structural concept for instructional carrels, particularly in public education. This design (Figure 26b) by the Worden Company, Holland, Michigan provides a 30" x 34 1/4" worksurface in a 36" x 36" x 56" (H) enclosure. The design is set apart from others of the same type by the innovative design of the mounting system for the projection system used in the carrel. The projector unit is mounted on a platform which allows vertical adjustment to compensate for lens location and alignment. Similarly, the viewing unit (a mirror and rear projection screen) are fore and aft adjustable to compensate for differences in projector lens focal length.

Design VII

The carrel designs described in the previous paragraphs are primarily intended for use at the information acquisition and demonstration levels of learning. Design VII while it is usable at these levels is primarily intended for use during the practice level of learning. Designed by Dr. E. A. Smith, this carrel is somewhat unique in that it is intended primarily as an environment for the integration of "carrel" and "workbench"


HIGH INTENSITY LAMP

(a)

(b)

Figure 26. Design V/Design VI.

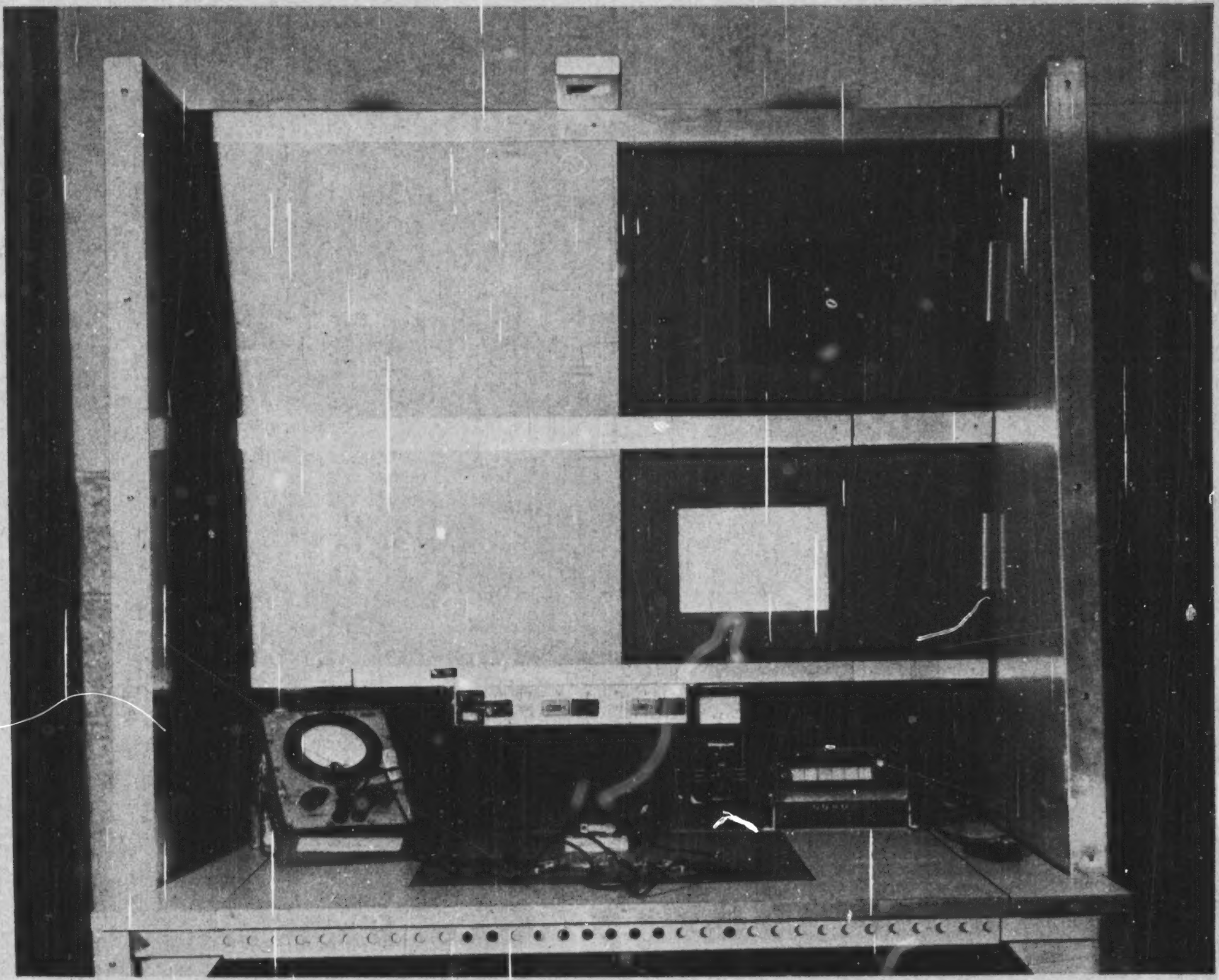


Figure 27. Design VII.

activities. A modular system, the carrel (see Figure 27) is designed specifically to facilitate hands-on training at the demonstration and practice levels. The carrel is physically expandable to accommodate various size equipment, has the structural integrity to support typical training and operational equipment, and is equipped with a well in the worksurface suitable for equipment placement or back lighting of small objects. The system can accommodate two rear screen projector modules and is uniquely configured to accept a third projector designed to provide step by step instruction or confirmation for complex procedural tasks such as circuit tracing,troubleshooting, etc.

This carrel, like the previously described, represents specifically designed solutions to specific aspects of the general technical training problem. These carrel designs, are not sufficient to provide for the full spectrum of mediation that is possible in improving technical training, but they do represent a substantial step in the right direction.

Stand-Alone Presentation Devices

Within the context of this study "stand-alone" presentation devices have been defined as that class of devices which are capable of presenting integrated audio-visual presentations while requiring only electrical power in order to operate. Stand-alone devices defined in this manner possess certain obvious characteristics and functional capabilities which make them particularly suitable for use in the technical training environment. Before proceeding with the description of the applications for stand-alone devices in Air Force technical training, it is appropriate that the technical characteristics of these devices be explored in more detail.

Stand-alone devices, typically, are composed of a projection system, audio component, screen, and the structural system inclosing all the components. At the present time the largest number of these devices employ rear projection optical systems. Stand-alone devices are presently available in 35mm slide, 35mm filmstrip, 16mm filmstrip, Super 8mm filmstrip and Super 8mm movie film formats. The audio-visual directory (NAVA, 1972) lists 25 manufacturers and at least 45 stand-alone devices as being available. The quality and sophistication of available self-contained devices vary over a wide range with a similar spread in cost, ranging from devices which are simply viewers and tape decks in a common housing requiring all functions (stop tape, change image, etc.) to be performed by the trainee, to sophisticated viewing systems capable of varying speeds of projection, of pausing or stopping, and of accepting and recording student responses prior to proceeding.

For use as part of a program of individualized technical training, stand-alone devices are seen as requiring at least the following technical characteristics:

1. Ideally the stand-alone device(s) selected will complement the media systems employed in the display module of the instructional environment. It can complement these media in one of two ways: it can use the same "software" (film slides, tapes, etc.) without modification or it can be for a different media entirely.

2. If the stand-alone device is selected to provide portability, or is intended for after-hours study of material presented in the instructional environment, then it must accept those material without modification of format or packaging (e.g. filmstrips used in the study carrel should not require special cartridges to be used in the stand-alone device; tape cassettes used in the carrels should not have to be re-recorded on cartridges, etc.)

3. If the stand-alone device is intended for supplementary, enrichment or remedial instruction, then consideration should be given to selecting a medium or format which differs significantly enough from the regularly used instructional media to allow the student to understand that the intent and purpose of this material is different from the day-to-day instructional material.

4. The design characteristics of the stand-alone device should meet the same criteria for ease of use, and ease of maintenance that one would impose on equipment to be used in the regular instructional environments.

In order to support individualized instruction in the baseline courses, we have in the previous pages described our selected and alternative concepts for an instructional environment. Certain stand-alone device concepts are seen as representing definite assets to such a system. Specifically stand-alone devices for cartridge-load Super 8mm films and for filmstrips are seen as being required parts of a total instructional environment for individualized technical training.

Stand-alone devices employing cartridge loaded Super 8mm movies are seen as satisfying the instructional requirement with the desired flexibility with respect to the use of this medium. Our analysis has not identified a substantial requirement for the use of motion pictures; however, we have tentatively outlined the requirement for their use in certain blocks of the PME course. In addition, the use of motion pictures for motivational or supplementary instruction is seen as being particularly useful.

Stand-alone devices employing the selected filmstrip format (35mm or 16mm), with the associated audio presentations, are seen as required to support after hours study and review requirements, particularly in the first part of the PME course.

Computer Interface

All of the media, display systems, and structural concepts described thus far have been selected and/or designed to operate under a system of control and/or management which can, in its most sophisticated form, be described as electronic, but in most instances as a simple electromechanical. Computer management or assistance to the instructional process has not been employed as one of the criteria in the evaluation and selection of previously described equipment and concepts. At the direction of the contracting agency, the previously described systems have been designed to operate without interfacing with any form of computer system.

However, it is both reasonable and prudent to consider the ramifications of computer assisted or computer managed instruction with respect to the development and implementation of instructional environments and instructional media systems. Without undue elaboration, computer managed instruction (CMI) is defined as the use of logical machines and systems to control or manage an individuals instruction. In a crude form, CMI simply automates the scheduling function of an instructional system. In its most highly refined form - approximated by the IPI (Individually Prescribed Instruction) system developed at the University of Pittsburgh, or by the Navy's CMI program at Memphis - a CMI system is capable of providing diagnostic evaluation of student progress, prescription based on past performance and, to a limited degree, actual control of the instructional media used. Computer Assisted Instruction (CAI) is the use of the computer in an interactive fashion, to control or monitor the learning process of an individual and to modify that process to achieve previously specified goals.

CMI systems, at their present level of development, have been based on modified batch processing computer systems. The students, and the instructional environment as a whole, have been restricted in their computer interface to input-output devices which have accepted information about student progress and output the next event (block of instruction, class, particular lesson package, etc.) the student should undertake. In this configuration CMI has served as a high level scheduling system with record keeping and simplified scoring modules of student performance. In a few of the more highly refined CMI systems attempts have been made to have the scoring and record keeping functions input their information to a decision model which could then "prescribe" for an individual student. Little, if any, work has been done to link, physically or electronically, the input/output functions of the computer system and any other element of the instructional environment for CMI.

The instructional environment concept and prototype developed during this study is as amenable as any other form of instruction to management and support by CMI systems as they presently exist. The development of CMI systems capable of finer control of the instructional sequence or the development of CMI modules capable of continuous monitoring of such parameters as frame or media selected, delay times, and answer patterns with subsequent prescription, would require the development of presentation system components capable of direct integration and control by computer.

Presently available CAI systems, among them the IBM 1500 and the University of Illinois PLATO III system, possess a degree of control over the presentation of material from visual and audio sources. This capability of controlling the stopping, starting and the sequence of audio-visual presentations is one of the benefits that a CAI system can provide. At the present time there exist only a limited number of audio or visual presentation devices capable of direct computer control. The available audio-visual system components capable of direct computer control are a 35mm slide projector manufactured by GAF, which used a built-in electronic switching matrix to acceptable digitally coded signals designating the visual to be projected, and the Plasma Display System, manufactured by Magnavox, which provides a digitally addressable microfiche and audio system.

Since AIDS was designed to operate independently of direct computer control, none of these components have been included in AIDS or the prototype instructional environment. However, AIDS has been designed in such a way that it will accept a limited number of digital commands with the aid of a relatively simple interface. Since AIDS presently operates on electrical signals originating with the logic circuitry designed into AIDS, it would be a relatively simple matter to convert the course of these signals from the presently used frequency signal to direct impulses from the computer system. AIDS, as it is presently designed, will also accept the GAF 1000 projector in either of its two projector positions, thus permitting direct computer control of the visual presentation available from AIDS.

The Plasma Display System is not presently designed to manage the operation of other forms of mediated instruction. Thus, if its capabilities are required in the instructional environment under discussion, it would operate in parallel with other forms of mediated instruction selected for use in that environment.

In the instructional environments developed during this study, the primary interface between the student and the computer system would consist of multiple-choice test instruments, answered by the student on a computer compatible punch card or mark-sense sheet, which is fed into some type of scanning device. The output from that scanning device is conveyed to the computer electronically. The feedback to the student could take any of several forms, but would most probably be in the form of a hardcopy printout.

In configuring instructional facilities for individual training, the facilities designed will have to give consideration to the placement and design of a hardcopy input/output "station " that would incorporate devices with the functional characteristics described above. Planning for future facilities should at a minimum include the provision of adequate power, space, and conduit (for computer cabling) to accommodate computer input/output devices capable of sustaining direct student/computer interaction for examination and prescription.

Information Retrieval

Across the three baseline courses there is a common requirement for retrieval of information as an integral part of both training and operational activities. At present the only information retrieval system available is that developed by the individual to acquire the information he requires from the reams of textual data (in the form of TOs, catalogs, etc.) which constitute the existing data base in each of the three courses. In order to improve accessibility to these data bases and to improve both the utility and applicability of retrieved information, it is suggested that an information retrieval system be developed and implemented for use in each of the three courses.

The type of system developed and its role will vary across each of the three courses, but generally the information retrieval system(s) should be designed to perform the following functions:

1. Efficient storage of all current Tech Order (TO) data and other information required for task performance.

2. Proper indexing to the proper level in each data base.

3. Rapid retrieval of desired information.

4. Legible display of retrieved information.

Within each course the specific requirement driving the functions listed above will differ, both as a consequence of the data base and of the specific functional requirements of each of the specialities being trained. However, there is sufficient commonality across the four functions listed above to assert that a microform-based information retrieval system could be developed that would enhance information accessibility and facilitate task performance.

The following examples are offered to indicate how and to what extent microform-based information retrieval systems would impact the configuration and operation of the three courses.

1. Inventory Management. A very large amount of instructional time and student time in this course is devoted to accessing specific data items in various stock lists, catalogs, etc. This is training for the actual task; however, the logistical problems associated with providing up-to-date stock lists, catalogs, and other documentation to the large numbers of students in this course is a significant problem. In

order to alleviate certain of these logistical problems, it is suggested that a microform storage retrieval and display system capable of being accessed randomly be acquired.

2. Precision Measuring Equipment. Almost all calibration tasks performed in PME shops and in PME training are performed in accordance with the equipment manufacturers technical data and/or National Bureau of Standards (NBS) specifications and standards. This requires that the PME student be able to identify, access and retrieve specific pages of data from a large data base. Neither the manner in which this data base is accessed nor the form in which it is retrieved is critical to task performance. What is critical is the accuracy of the information and the rapidity with which it can be retrieved. A microform storage and retrieval system which will allow access to specific pages of data on a random basis is seen as being a desirable adjunct to the hands-on instructional situation.

3. Weapons Mechanic (TAC). All maintenance, installation and checkout tasks performed by weapons mechanics must be performed in accordance with the applicable TOs. The volume of this information base is staggering in that each student on each shift must have a copy of the TO applicable to the system he is presently studying. The logistics associated with issuing, returning, updating and maintaining this document store would be greatly eased by the adaption of a microform system; however, the nature of the instructional environment, and the constraints imposed by the present Air Force TO structure preclude the use of a microform system at this time.

A commitment on the part of the Air Force to micro-publishing for TOs and the development of truly self-contained retrieval and display systems might warrant further consideration of the application of microforms to this course.

Given that two of three courses represent areas where a microform retrieval system could be used, then what type of microform is most appropriate for application to the baseline courses?

A comparison of the four major classes of microform (microfiche, roll film, aperture cards and micro-cards) on the basis of their capabilities, limitations and cost with respect to those characteristics which have a direct bearing on the effectiveness of a microform storage and retrieval system resulted in the matrix shown in Table 7. The values in the matrix are simply the rank values assigned to each class of microform for the particular characteristic.

Examination of the summated scores for each microform in Table 7 reveals the following order of preference: (a) microfiche, (b) roll film, (c) aperture cards, and (d) micro-cards. This rank order is only a gross discriminator and certainly does not consider procured system cost which is the final arbiter. However, it does indicate that microfiche and roll film are significantly more appropriate for application here than either aperture cards or micro-cards. This statement is valid only in terms of the use of microform for storage of whole documents such as TOs, etc.

Having determined that either microfiche or roll microfilm represent the most desirable format for this application, the question becomes one of mechanization: What kind of system is best suited for the storage, retrieval and display of the type of information required in the IM and PME courses? Acknowledging the slight advantage provided by microfiche over roll film, it is anticipated that a system similar to HF Image Systems CARD system represents the level of capability desirable in this type of instructional environment.

The basic CARD system is an electronic desk-top information and display station with a capacity of 750 individually indexed fiche in a rotary magazine. Magazine capacity is extended through the use of recently introduced 50-fiche cartridges which are simply inserted into the magazine. In its basic form CARD is searched by use of a 12 character binary code entered using keys on the face of the unit; fiche meeting the criteria are displayed to user on the view screen. CARD can index to a specific page; however, broader searches result in display of the title page of the document(s) meeting the search criteria. The operator is able to scan a given document or may simply view the title pages of all documents meeting the search criteria. Mean response time for display of the first document is 4 seconds.

An advanced version of CARD is available which has the possibility of extending the instructional flexibility of the information retrieval function. SRD/COMPCARD operates basically in the same fashion as CARD; however, this system contains its own minicomputer (8K bytes), a typewriter I/O, and a unique magnetic tape cartridge system to provide a compact, but fairly complex, index manipulation and document display capability. Use of the integral computer system provides the flexibility inherent in computer based document searching while avoiding the complexities and problems associated with time shared systems. The magnetic tape cartridge files are primarily used to hold the inverted files which form the basis of all search operations. Each cartridge stores 64,000 characters and any single character is accessible in 0.5 seconds; cartridges are easily changed and are relatively low in cost, allowing the creation of a substantial local data base that can provide direct instruction as well as simply display information.

Characteristics	Micro-Fiche	Roll Film	Aperture Cards	Micro-Cards
CAPABILITIES:				
o Rapid input preparation	3	3	3	1
o High storage density	3	4	1	2
o Easy to update	3	2	4	1
o Rapid information retrieval	2	2	2	2
o Minimal storage space	4	3	2	1
o Easy to duplicate microform	4	2	3	1
o Easy to generate facsimile	4	4	3	1
LIMITATIONS:				
o Suitable for duplication	4	4	3	1
o Local production presently possible	4	4	2	0
COST:				
o Purchase Cost *	3	3	2	0
o Per document cost				
-high volume *	2	3	1	1
-low volume *	3	3	1	1
o System operation *	4	3	2	0
TOTAL	43	40	29	12

*Least costly receives highest ranking.

Table 7. Comparison of microform characteristics

VI. FACILITIES

Facilities requirements have been addressed in terms of equipment, facilities, processes and personnel required for the production of prototype and refined material and for the processing, reproduction and storage of: (a) still-visual material, (b) transparencies, (c) prints, (d) motion picture materials, (e) microform materials, (f) video tape, (g) audio materials, (h) audio tapes, (i) movie soundtracks, and (j) audio based control systems.

A specific set of processes and functional equipment characteristics are identified as representing the optimal solution to a specific set of media production, processing, reproduction, storage and distribution problems. Since these problems are peculiar to the instructional environments and types of technical training described in this report, the media production facilities described here represent a special purpose solution.

Still Transparency Facility

As stated in this report, the primary media will be still-visuals with associated narration. The largest percentage of those visuals will be transparencies in one of three formats: 35mm slides, 35mm filmstrip and 16mm filmstrip. Production, processing, and duplication of instructional material in these formats share enough common features that they will be treated together. Specific differences in equipment, technique, or facility requirements will be treated only as deviations from what is common to all three formats.

Prior to any production of transparencies, it is assumed that some form of production organization has been established to coordinate and schedule the effective use of available resources and manpower. Assuming for the moment that the photographic unit under discussion is operating independently of the existing base photo group, then first consideration should be given to staffing and equipping such an operation.

Staffing

The minimum staff required to perform the functions and tasks associated with the production of transparency materials to support individualized technical training in the three baseline courses will consist of three types of personnel.

The first type will be competent and experienced photographers skilled in photography in several formats, but with an emphasis on 35mm still photography. They must also have a background in such aspects of cinematography as continuity and be capable of creating still sequences rather than isolated shots. They will be responsible for obtaining all live action and in-the-field shots required to support instructional materials development. At least one of these individuals must be a skilled copy technician, since a large percentage of the visual materials required in instructional presentations are based on graphics and textual material. The most important aspect of these individuals' qualifications must be attitude and motivation. These individuals must be creative and innotative within the bounds imposed by the instructional materials and must be willing to try new techniques and equipment that will result in visuals that are effective teaching tools. A minimum staff of three photographers will be required.

The second type of personnel required will be skilled photo processing technicians. At least two and possibly three photo technicians will be required to operate and maintain the facility's functional capability with respect to photo processing, duplicate generation, and quality control. The most important aspect of these persons background will be their experience in operating a moderate size, high-volume operation such as will be required to support even a moderate program of conversion to mediated instruction.

The third type of personnel required will be support personnel. These personnel will be responsible for the operation of film cutting, loading, slide mounting and packaging equipment. Specific duties for these personnel will include operation of the slide mounting/film cutting equipment, segregation of slide sets, filmstrip cutting and cartridge or slide tray loading and labeling. In addition, they will support the photo technicians with specific tasks under supervision. A minimum of two individuals will be required.

It should be emphasized that the manning levels specified above are for technical personnel only and do not include the administrative or clerical support personnel required to keep a tightly scheduled and minimally staffed organization functioning properly. Satisfying the requirement for this support will require one administrator/manager and one clerk/typist.

Transparency Preparation

The specific decision as to which still transparency format to standardize upon must remain the judgment of the Air Force. The results of our analyses of the technical quality, subjective quality, and producibility indicate that any one of the three formats (35mm slide, 35mm filmstrip or 16mm filmstrip) will produce high quality images suitable for individual and small group presentations, provided the correct types of equipment are available. With respect to the relative cost effectiveness of the three formats (see Table 8), 35mm filmstrip seems to achieve the lowest cost per instructional package. The cost advantages accruing to the use of 16mm film are offset by the relative high cost of the cartridges required for this format. The addition of this cartridge cost and the associated labor costs elevates 16mm filmstrip from the lowest cost option to a cost substantially higher than 35mm filmstrip.

The summary cost data provided in Table 8 and amplifying data presented in Tables 9, 10, and 11, are based on the conversion of the three baseline courses during the same time period.

1. Original Transparency Generation. Experience has shown that on the average, at least one-half of the frames in instructional packages are "live" action shots. The remaining frames consist of titles, textual, graphics, or tightly arranged "studio" shots. In this context, one of the primary pieces of equipment in the transparency preparation facility will be its copy camera system. These devices are specially designed high volume production cameras and associated lighting and positioning systems that have evolved from the animation camera requirements of the commercial motion picture field. Representing a very specialized aspect of still camera development with a rather restricted market, this type of device is produced by a limited number of firms. The market is dominated by four firms: Acme, Forox, Oxberry and Sickles.

Using input materials of differing format, size or types (e.g., artwork, transparencies, etc.), the rate of production would be paced by the operators performance in positioning, lighting and balancing each different form of input. Because of the high production volume that can be expected to occur in the facility described here, every effort should be made to reduce the requirement for adjustments and settings between sequences or individual shots. The best way in which to successfully accomplish this reduction in adjustment and setup time is to establish standards for image quality.

One system for accomplishing this has been developed by Smith. This system requires that all original artwork, titles, and live action shots be prepared as 8 x 10 color prints. The actual image size is 6 1/4" x 9 3/8" printed uncropped from 35mm negatives on 8 x 10 photo paper. Title frames, graphics and other artwork would be prepared in the 8 x 10 format as well. These serve as the master file for all presentations and provide a uniform size and aspect ratio, and a relatively uniform reflectance ratio for all input material. This technique allows modified or updated programs to be produced from originating material or equivalent quality prints rather than from second or third generation transparencies. This allows subsequent copies to be generated in a manner identical to the original without problems imposed by dust and increased contrast due to copying and recopying.

This technique offers the advantage of uniform input size and relatively consistent input quality while reducing the requirement for maintaining files of masters, negatives, etc. It also allows the production of 35mm slides, 35mm filmstrip and/or 16mm filmstrip from the same artwork. This in turn allows the production of software independent of specific hardware considerations. The prints and artwork form the master file and the working copy from which successive generations of the

Item	35mm Slide	35mm Filmstrip	16mm Filmstrip
Cost of 10 Units (Film)[a]			
Photo Labor Cost	(Same for all formats)		
Container Cost	$17.30	$ .60	$28.00
Packaging Cost	4.00	1.00	2.00
TOTAL COST	$21.30	$1.60	$30.00
Cost per Copy	$ 2.13	$ .16	$ 3.00
Storage Requirements			
"Typical" Package Volume	220 Cubic in	3.5 Cubic in	37 or 45 Cubic in (including sound track)
Per Frame Volume	2.75 Cubic in 2.20 " " 1.57 " " (Depending on number of slides in tray)	.04 Cubic in for a 72 frame filmstrip	.37 Cubic in per frame for a 3 ft long (120 frame) strip

---

[a] Given that equipment, facilities, and staff are available; costs are for visual images only.

Table 8. Production Cost Summary

Item	Inventory Management Course	Precision Measurement Course	Weapons Mechanic Course
1. Total Course Hours	240 Hours	1,200 Hours	640 Hours
2. Hours of Mediated Instruction	100 Hours	120 Hours	235 Hours[a]
3. Frames per Hour of Instruction	72 Frames	72 Frames	72 Frames
4. Frames per Course (2x3)	7,200 Frames	8,640 Frames	16,920 Frames
5. Revision per Year (10%)	720 Frames	864 Frames	1,692 Frames
6. Total Frames per Year (4+5)	7,920 Frames	9,504 Frames	18,612 Frames
7. Number of Sets Required[b]	42 Sets	18 Sets	6 Sets
8. Production Requirement (6x7)	332,640 Frames	171,072 Frames	111,672 Frames
9. Total Production Requirement			615,384 Frames

[a] Includes multiple copies presenting each team member's discrete tasks during complex team functions.

[b] Figures adjusted to include reserve sets as required based on accepted standard of 20 percent of units estimated for maintenance purposes or replacement plus units for administrative use and review.

Table 9. Still-Visuals Baseline

COURSE	NUMBER OF IMAGES REQUIRED	ORIGINAL FOOTAGE REQUIRED ①			INTERNEGATIVE FOOTAGE REQUIRED ②			DUPLICATE FOOTAGE REQUIRED (SEE TABLE 2-2) ③			PACKAGING		
		35 MM SLIDES	35 MM FILMSTRIP	16 MM FILMSTRIP	35 MM SLIDES	35 MM FILMSTRIP	16 MM FILMSTRIP	35 MM SLIDES	35 MM FILMSTRIP	16 MM FILMSTRIP	CUTTING & MOUNTING 35 MM SLIDES	CUTTING & CANNING 35 MM FILMSTRIP	CUTTING & CARTRIDGING 16 MM FILMSTRIP
INVENTORY MANAGEMENT	7,920	2,750	1,376	550	1,375	688	275	43,750	21,815	8,750	253,440 SLIDES	3,520 PRINTS ④	3,520 PRINTS ⑤
PRECISION MEASUREMENT EQUIPMENT	9,504	3,300	1,650	660	1,650	825	330	39,600	19,800	7,920	228,096 SLIDES	3,168 PRINTS	3,168 PRINTS
WEAPONS MECHANIC	18,612	6,462	3,232	1,292	3,231	1,616	646	103,400	51,700	20,680	595,584 SLIDES	8,272 PRINTS	8,272 PRINTS
TOTAL	36,036 IMAGES	12,512 ft.	6,502 ft.	2,502 ft.	6,256 ft.	3,129 ft.	1,251 ft.	186,750 ft.	93,375 ft.	37,350 ft.	1,077,120 SLIDES OR 14,960 TRAYS	14,960 PRINTS	14,960 PRINTS
FILMCOST ⑥		$ 2,888	$1,444	$ 225	$1,085	$ 620	$ 103	$ 5,509	$ 2,754	$ 507			
PHOTOGRAPHIC LABOR ⑦		$ 5,764	$5,764	$5,764									
PROCESSING COST ⑧ (6¢ per foot)		$ 756	$ 378	$ 156	$ 378	$ 192	$ 78						
PRINTING COST ⑨ (5¢ per foot)								$ 9,338	$ 4,669	$ 1,868			
CARTRIDGE COST ⑩											$ 25,880	$ 898	$41,888
PACKAGING COST ⑪ ⑫ ⑬											$ 53,856 ⑪	$ 1,496 ⑫	$ 2,992 ⑬
TRAY FILLING COST ⑭											$ 5,984		

Table 10. Production Cost Data

BEST COPY AVAILABLE

1 Assumes a 2:1 shooting ratio.

2 Internegatives are generated after editing to permit high quality duplicates to generated. Internegative film used is assumed to be:

35 MM, Eastman Color Internegative, 6008 ($155 per 1,000 ft.)

16 MM, Eastman Color Internegative, 7271 ($103 per 1,200 ft.)

3 Duplicates are assumed to be release printed on:

35 MM Eastman Color Print, 5385 ($32.50 per 1,000 ft.)

16 MM Eastman Color Print, 7385 ($21.42 per 1,200 ft.)

4 Filmstrips are assumed to be 72 frames in length - excluding leader and trailer. The required number of filmstrips is assumed to equal the number of instructional hours times and required number of copies.

5 Each 16 MM filmstrip cartridge is assumed to hold 3 ft. of film including leader and trailer.

6 Original Frames are assumed to be photographed on 35 MM Eastman Ektachrome MS, 5256 or on 16 MM Eastman Ektachrome Commercial 7252 purchased in bulk and would and cut on site:

35 MM = $22.92 per 100 ft.

16 MM = $26.40 per 400 ft.

7 Photographic labor cost based on following rationale:

36,036 prints to be copied - copy camera operator capable of shooting 25 prints per hour = 1441 hours of copy camera time. Assumed labor rate is $4.00 per hour - cost is

$$\begin{array}{r} 1441 \\ \underline{\text{X } \$4} \\ \$5,764 \end{array}$$

8 Includes amortized equipment, chemicals, facilities and labor cost (this cost represents what can be obtained commercially).

9 Printing cost includes amortized equipment, processing, facilities and labor costs. and labor costs.

10 Cartridges are assumed to be Audiscan or equivalent at $2.80 per cartridge for 16 MM filmstrips; Bell & Howell or equivalent for 35 MM filmstrips at $0.06 per cartridge. Slide trays are assumed to be Kodak Carousel Universal slide trays or equivalent at $1.73 per tray.

11 Cost includes slide cutting, mounting in cardboard mounts and packaging as a set; includes amortized equipment, materials, facilities and labor costs. Cost is seen as $0.05 per slide.

12 Cost includes cutting filmstrips to proper length, winding and insertion into cartridge or can; includes amortized equipment, materials, facilities and labor costs. Cost is seen as 10¢ per print.

13 Cost includes cutting filmstrips to proper length, splicing and insertion in cartridge; does not include cartridge cost. This cost does include amortized equipment, facilities and labor cost. Cost is seen as 20¢ per cartridge.

14 The cost of packaging each slide set in a tray is set at $0.40 per set. Each set is assumed to consist of 72 slides requiring orientation and insertion in standard Carousel trays.

Origination Equipment

-Filmstrip/Slide Process Camera (Forox Model SS or equivalent) and/or	$ 9,000
-High Volume Copy Stand (Leitz Repovit or equivalent) (optional)	$ 2,000
-35 mm Cameras (6) ($400) (Pentax Spotmatic, Nikon, Leica or equivalent)	$ 2,400
-Lens Systems (estimated)	$ 3,000
-Accessories (Tripods, strobes, etc.)	$ 1,000
Total	$17,400

Processing Equipment

-Film Processor, ME4 Process Chemistry, Continuous run processing (Cintel Model LTM-ME4, Sickles Automatic Film Processor, Bell and Howell 036204 or equivalent.)	$10,000
-Equipment and materials for small batch processing (E-4/E-3 chemistry)	$ 1,000
-Film Drying Cabinet (estimated)	$ 500
Total	$11,500

Printing Equipment

Loop type optical printer (20 ft per minute capacity; darkroom operation)	$ 2,500
or	
High speed optical or contact printer (ACME or equivalent)	$20,000
or	
Vertical Optical Printer (can print from slides or filmloop)	$ 8,000

Finishing Equipment

-35 mm automatic slide mounter *1 (30 slides per minute)		$ 8,000
or		
-35 mm film cutter and slide mounter (2 distinct units manually operated 10-15 slides per minute)		$ 1,050
-35 mm film cutter for filmstrips *2		$ 500
-Hand Rewinds *2		$ 100
and/or		
-16 mm film cutter w/frame counter *3		$ 200
-16 mm butt splicer		$ 250
Total	$2,100 —	$ 9,050

*1 A unit of this capacity and cost is only justifiable if large scale distribution in the 35 mm slide format is anticipated. The smaller scale operating capability would adequately service prototype development activities.

*2 There are no commercially available film strip cutters and winders. The commercial filmstrip laboratories have designed and fabricated systems that meet their particular requirements. The elements identified here would allow the fabrication of a manual cutting and winding system.

*3 There are no commercially available 16 mm filmstrip handling or cutting systems. It is assumed that the few commercial organizations handling this format have designed and built their own equipment. The price cited here is for a 16 mm editor splicer which could serve the desired purpose.

Table 11. Transparency Facility Equipment

same or updated presentations can be generated. In a properly functioning operation, use of this system would provide for the generation of 16 and 35mm filmstrips with a flexibility akin to that possessed by 35mm slides. The basic philosophy underlying this approach is to create a uniform format for all data to be included in still-transparency presentations. This requires that pictorial images and photos be enlarged to an 8 x 10 image size and that title, graphic and textual artwork be reduced to fit within the same image area.

Photos of procedural and on-equipment tasks should be produced with the direct assistance of responsible instructional personnel even to the extent of using the instructor as the photographer for his own segment of instruction. Instructor-generated photography, even that which is not of presentation quality, is an invaluable assist to all phases of instructional development. The importance of this kind of imagery has been pointed out by Smith (1971) with respect to the use of portable video equipment. His comments are equally applicable to instructor generated photographs.

Based on the general philosophy and operating principles specified above, the equipment listed in Table 11 constitutes the functional capabilities required to adequately support the development of audio-visual presentations. With the equipment described in Table 11, the functional operation of the transparency production function can be described as follows.

Upon receipt of a request for a series of images answering the requirements of a specific script or storyboard, the assigned photographer will meet the instructor, script-writer and instructional development representative to establish specific shots such as live action, graphics, etc. After having established the requirements for each shot in the script or storyboard, the photographer will coordinate with the instructor to arrange all live action shots. Live action shots are recorded as 35mm color negative images using standard 35mm equipment. All flatwork and copywork will be photographed in the studio using 35mm color print film and proper compositional aids and lighting.

The imagery from both sources will be processed. The resulting slides will be reviewed by the instructor, scriptwriter, and instructional developer to determine whether the imagery accurately portrays the script and/or whether the script should be modified to accommodate the imagery. Following this, the material will be given an initial tryout on a small group of students to verify its instructional adequacy. Assuming that no changes are required in the imagery on hand the steps described in the following sections will result in the required number of instructional sequences.

2. Multiple Copy Generation. The masters being used are 8 x 10 color prints and similarly formatted artwork. To generate the required number of copies for each instructional sequence, these prints will be placed in the sequence of the final script, with all title, focus, and security marking frames in the proper places. These prints will be photographed on a slide/strip process camera. Depending on the number of copies required, the material will be photographed using a reversal or negative film. In those instances where 12 or less copies of a sequence are required a reversal film such as Kodak Ektachrome 5256/5242 (35mm) or 7256/7242 (16mm) will be used to directly copy the required number of sequences. When more than 12 copies are required a negative film such as Eastman Color Negative Film 5254 (35mm) or 7254 (16mm) might be preferable.

The resulting negatives can be contact or optically printed onto Eastman Color Print Film 5358 (35mm) or 7358 (16mm) to produce properly sequenced, ready to mount and/or distribute visual presentations.

To assure the establishment and quality of duplicate transparency materials the facility must have available the proper equipment and personnel to provide proper quality control of the printing process.

Personnel to satisfy this requirement are extremely difficult to specify since the formal course work and training for this type of work is considerably less important than the experience and skill possessed by a given individual. The photographic laboratory technician, is responsible for matching the characteristics of the original or negative master to the emulsion characteristics of the print film, to the optical and illumination characteristics of the print film and to the optical and illumination characteristics of the printer. These tasks have consistently been described by both equipment manufacturers and processing laboratory personnel as an art rather than a science. While the physics of the process of printing are quantifiable, the number of variables operating during the process is sufficiently large that only the intervention of the technicians skill can reduce the uncertainty to an acceptable level.

Equipment required to assure the quality of multiple color prints will include densitometry equipment designed to measure the color characteristics of negatives and prints. This type of equipment and the procedures involved in its application, have been developed primarily for use in the processing and printing of commercial movie film. It is assumed that both 35mm and 16mm filmstrip printing will proceed in exactly the same manner as movie film printing. The production of large volumes of 35mm slides will occur in the same manner as filmstrip or movie film during printing and processing.

The actual printing of duplicate copies of filmstrips or slide sequences can be accomplished by either contact or optical step printing. The recommended technique for the technical training media facility is optical step printing. This recommendation is supported by the following rationale:

1. At the present time there are no commercially available medium volume contact printers for transparencies.

2. Optical printing produces equivalent quality to contact printing in the films and resolution ranges under consideration.

3. The optical printer capability required for filmstrip or slide sequence duplication may be time shared with the motion picture processing portion of the media development facility.

The equipment and procedures available for the production of duplicate filmstrips and slide sequences are of three types:

1. A vertical optical printer on which the internegative, or original transparencies can be printed onto print film.

2. A high speed optical step printer with which the original footage or an internegative can be printed onto print stock at higher speeds than are possible with the vertical optical printer.

3. The slide/strip process camera can be used as a printer by exposing original artwork, 8 x 10 color prints or color slides on reversal film. This alternative does not involve the use of a printer per se; rather it employs the slide/strip process camera as an optical printer.

Each of these approaches to the volume production of transparency materials has certain disadvantages and advantages which need to be traded-off against the particular requirements inherent to the technical training media development facility.

The vertical optical printer requires subdued light operation, permits full color correction (through an additive light system) and automatic exposure setting. This option is limited to the production of 35mm slides or filmstrips only. This device is rapid enough to handle the volume requirements of the facility.

The high speed optical printer has the advantages of the vertical optical printer as well as variable printing speed ranging from 1 to 160 feet per minute, the ability handle both 35mm and 16mm footage on the same device, plus the ability to optically reduce footage from 35mm to 16mm, 16mm to 8mm, or 35mm to 8mm. This type of unit also permits optical blowup of footage from 8mm to 16mm or 35mm and from 16mm to 35mm; however, this variety of features is only achieved at a substantial cost from a limited number of custom manufacturers.

Using the slide/strip camera is generally less costly in terms of equipment (assuming that a slide/strip process camera is already available) but is more costly in terms of time required per transparency sequence and in terms of labor dollars per transparency sequence. It is, however, an efficient method for the generation of up to 12 copies of a given presentation.

Depending on the transparency format selected, the following recommendations are made:

1. If 35mm (single frame or double frame) is the selected format, then the vertical optical printer would be able to support an effort of the magnitude described in Table 9.

2. If 16mm is the selected format, or if the production volume greatly exceeds that specified in Table 9, then option b, the optical step printer, is recommended.

3. A rationale supporting the selection of b as the best overall choice can be made if one considers its additional utility in support of the motion picture development facility.

4. The process camera should be available for the production of prototype materials and for the development of runs of under 12 copies or when larger volume equipment is occupied or down for repair.

Processing

Original and print film processing can be accomplished in the same types of equipment, but slightly different chemistry is required for each. Assuming that the origination footage is shot on Ektachrome type films, then E-4 process chemistry will be required. For 5385 film, ME-4 chemistry (similar to E-4 but designed for continuous process machinery) is required. If 5386 is selected as the release film (original printed directly to 5386 without an internegative) then E-2 and E-3 chemistry will be required.

If Internegative Color Film 6008 is used then C-22 process chemistry will be required as well.

Preparation and Packaging

Once the required number of prints have been made and the film processed, the transparency production facility must contend with the problems associated with cutting, mounting and/or packaging each presentation. Depending upon the format selected, one of the following sequences will become applicable:

35mm Slides

1. Cut print stock.
2. Mount images in cardboard mounts (preferably numbered consecutively within sets and printed with lesson identification data).

3. Box slide sets for later traying and/or insert slides in trays.

4. Label trays or tray containers with lesson identification data and date.

Filmstrips

1. Cut print stock to appropriate lengths.

	35mm Filmstrip	16mm Filmstrips
2.	Wind each length as either A or B wind.	Butt splice film lengths into continuous loops.
3.	Insert wound lengths into cartridges/cans.	Insert loops into cartridges.
4.	Label package with lesson I.D. and date.	Label cartridges with lesson I.D. and date.

Automatic, semi-automatic, and mechanical systems for cutting and mounting 35mm slides are available. If 35mm slides are selected as the primary medium of instruction then the investment for an automatic cutting and mounting system is a definite requirement to meet required output levels. If slides are not to be used as the primary media, then an investment in motorized cutting and mounting equipment would still seem to be required to facilitate the development of prototype materials.

No commercially available filmstrip cutting equipment exists at the present time. To mechanize the process of filmstrip sizing, a system could be developed from commercially available film rewinds of the proper size and a filmcutter. For 16mm filmstrips, an editor with frame counter and cutter attached could serve the same purpose. For both filmstrip formats the take-up rewind spools should be of the "break-down" type to permit each successive filmstrip to be removed. For 35mm the filmstrips can be inserted directly into the cartridge or can from the rewind. For 16mm filmstrips butt-splicing is required prior to insertion into cartridges. This requires the use of an automatic film splicer in order to assure strong, jam-proof splices.

The accurate cutting and precision splicing required for 16mm filmstrips is a requirement of the synchronization system used in present 16mm filmstrip systems. Each image (including leader) is accompanied by a pulse on the associated audio tape making it critical that the precise number of frames be present in every copy.

When the 16mm film-loop has been placed in the cartridge, the task of filling the cartridge is only partially completed. Available 16mm cartridges, as designed, incorporate audio tape directly within the film cartridge body, thus the partially filled 16mm cartridges will have to be moved to the Audio Facility for tape filling and final packaging.

The traying and the cartridge filling of slides and filmstrips will be manual operations, there being no known equipments or systems for these tasks.

As can be seen from the costs associated with these activities in Table 8, labor intensive operations such as these represent a sizeable portion of the overall cost. In this respect, 35mm slides are the most costly format of the three, because each image is mounted, and inserted as a separate entity. Not only must each slide be handled separately during insertion, each slide must be sequenced and correctly oriented prior to insertion in the tray. This combination of tasks is extremely time consuming and it is critical since the inversion of one slide or the mis-sequencing of slides can destroy the effectiveness of a presentation.

Sixteen millimeter filmstrips are next in cost. This is attributable to the cost of the cartridges for this format. The low cost associated with the 35mm filmstrip format is attributable to the ease of loading 35mm cartridges and the feasibility of mechanizing the winding process for this format.

As trays or cartridges are filled, they should be labeled immediately with previously prepared pressure sensitive labels identifying the lesson material and either its preparation date or revision number. After all copies of a given lesson or instructional presentation are packaged, they should be moved out of the transparency facility, either to a storage area to await combination with audio materials, or directly to the appropriate instructional department.

Facilities Requirements

1. Space Requirements. The exact floor space requirements for a transparency generation capability will, of course, vary to the extent to which it shares facilities with the photographic print and motion picture operations. Assuming for the moment that the transparency generation facility is an independent physical entity, it can be stated that the minimum area required for a facility employing a continuous film processor would be 1800 sq. ft. (including office space, studio area, and storage for operating supplies). Additional storage space for chemicals, filmstock (if kept on hand), mounting supplies, trays/cartridges, and other packaging materials will be required as well.

The following functional areas will be housed within the transparency generation facility;

Space	Function
Office Area	Administration, scheduling, facility files.
Studio Area	Generation of pictorial imagery.
Copy Room	Slide/strip process camera for generation of original transparencies from flatwork and/or transparency duplication. (Vertical optical printer could be located here if selected).
Projection Room	Preview of transparency sequences prior to duplication (actually will share studio space, but requires space for projection equipment).
Color Film Processing Room	Processing equipment located here will include provision for large continuous processing and small batch (1-5 rolls) processing (300 sq. ft. minimum).
Color Printing Room	If a large optical printer is used a separate room with subdued lighting and a semiclean room environment should be established. The use of a vertical optical printer or the process camera as a printer would eliminate this requirement.
Chemical Storage and Mixing Area	This area will be used to store chemicals for all processing operations and will serve as the preparation area for all bulk processing solutions.
Finishing Room	Transparency materials will be cut, mounted, sorted and packaged in this area.

This functional breakout of space requirements is the best approximation of a physical design that can be achieved without the identification of the exact process and equipment to be incorporated in these spaces.

2. Ventilation and Air Conditioning. The provisions for ventilation and air conditioning of the transparency generation facility are quite distinct from those required to satisfy the requirements of other instructional development spaces. Several functional spaces within the facility will generate noxious fumes, large amounts of heat and/or humidity and some will require special ventilation techniques. Specifically, the air conditioning and ventilation system must be sized and designed to handle the following problems:

Local Ventilation - Specific operations in the film processing room(s) will require ventilation hoods for the extraction of heat or noxious substances; ventilation hoods will also be required for the mixture of chemicals and for the film dryers.

Minimal Air Change - The total exchange of air in any given processing space should not exceed eight minutes; however, local conditions and equipment or process characteristics may require faster exchange rates.

Temperature - Temperature in all spaces should be maintained between 70-75° F. Because of the nature of processes involved in photographic processing this will require at least zone and preferably local control of the air conditioning system in order to balance the system for variations between process steps and equipment operating characteristics.

Humidity - Relative humidity should be maintained at 40 to 50% to reduce static electricity problems in the handling of film stock and finished transparency materials.

3. Water Supply. Fairly large amounts of fresh water will be required for the processing facility. Minimum flow rate for large scale processing equipment is 16 GPM with a pressure of 45 PSI. This input rate is the same for both cold and hot water systems (even though large batch processors have their own temperature regulation system - hot water is required for ancillary tasks and small order processing). All water entering the processing areas should be treated to achieve a hardness of 40 parts to 150 parts per million of Calcium Carbonate ($\mathrm{Ca\ Co_3}$) (Kodak, 1968) and filtered to remove solid and colloidal matter that might effect emulsion characteristics.

4. Power Requirements. Electrical circuits throughout the facility should be 110/115 volt, 30 ampere circuits at a minimum with the following exceptions:

Studio - Almost all studio equipment including lighting will be adequately served by 110/115 volt, 30 amp circuits, but provision should be made for 220 VAC, 60 cycle.

Processing Rooms - Continuous processing equipment requirements for power are a function of equipment capacity and processing speed and require 220 V 60 amps. Selection of specific equipment prior to facility design will allow circuitry to be tailored to its specific requirements.

Printing Room - Depending on the printing technique selected this area will require 115 volt, 30 amp or 220 volt, 20 amp power. The vertical optical printer and the process camera each require only 115 volt, 30 amps. Precision optical printers require 220 volt, 20 amps.

For convenience and safety each functional area within the facility should have its circuitry controllable locally. Constant voltage transformers should be used where required to maintain the integrity and quality of a specific processing or printing step.

5. Drying Facilities. In order to handle the large volume of transparency materials required in this instructional development facility, we have described a transparency processing capability predicated on the use of continuous flow processors for the largest volume of the processing to be accomplished. These processors are all designed to output dry footage, thus there is no requirement for large scale drying facilities. In order to support the requirements for small batches of film on an intermittent basis, there will be a requirement for a drying cabinet capable of accommodating 36 exposure rolls.

Photographic Print Facilities

The exact requirement for, and thus the magnitude of, a photographic print facility to support the development of instructional materials for individualized technical training will be determined by both the media selected for training and the materials development processes selected to support the production of those media.

There are two distinct requirements for photographic prints to support the development of instructional materials. The selected system for transparency generation relies on color prints with an 8 x 10 image area as the primary record and copy medium from which transparencies are generated. To support a transparency production operation of the magnitude will require an efficient color print production capability. In addition, there is a requirement for photographic print support to the graphic arts and text generation facilities.

With these responsibilities, it becomes evident that some form of print generation, copying, processing and finishing facility will be required to support the development of individualized technical training material. Primary responsibilities for this facility are assumed to be as follows: (a) Generation of color prints for use in the generation of transparencies. (b) Generation of black and white prints and photo masters for inclusion in texts, Job Performance Aids, and other forms of textual training materials. The assets required to support these responsibilities fall into the same categories as those for transparency generation but with different specifics.

Staffing

From the data contained in Table 12 and assuming a 2:1 shooting ratio at least 72,000 separate color prints would be required to support transparency generation. This requirement, plus half as many photographic prints for the support of textual instructional materials, establish the size of the staff required to man the photographic print facility. For present purposes, let us again assume that this facility is an independent entity with no commonality in staff or equipment with the transparency facility. Under this assumption, the staff required to man the print facility would consist of the following numbers and types of personnel.

1. Photographers. At least 2, and possibly 3, photographers will be required to adequately staff this facility. Their primary responsibility would be in the generation of black and white imagery, both live action and copy work, to support textual training material production.

2. Print Specialists. At least 3 individuals will be required to adequately staff this requirement. Primary duties for these individuals will be the production of 8 x 10 color prints from 35mm negatives, and the generation of required half-tone and continuous tone plates for inclusion in textual training materials. These individuals would be responsible for enlarging, color analysis, manual color print processing and whatever spotting and finishing is required.

3. Retouch Artist. At least one individual skilled in the art of retouching photographic prints will be required. His primary duties will involve correcting, annotating and adjusting photographic prints to enhance their instructional value.

4. Processing Technicians. Assuming that automated print processing equipment is used, at least one processing technician will be required to support the processing requirements of the facility. Two is probably a more realistic estimate as it provides for backup and for a longer work day (through differential, overlapping, or successive shifts) to meet peak demands.

The staffing structure suggested for the instructional development photo print facility is based on the use of photo plates produced by this facility to illustrate textual materials, and on the use of color prints as the record/master/source of transparency materials to be used as instructional materials. It is estimated that the staff requirements for a facility designed to provide only black and white print processing and photo plate production will be adequately staffed by three individuals, one from each of the three categories described above.

Print Preparation

Print preparation in support of instructional materials development is best treated in terms of two functionally discrete processes: the preparation, processing, and finishing of black and white prints and

	Inventory Management Course		Precision Measuring Equipment		Weapons Mechanics (TAC)		
1. TOTAL HOURS IN COURSE	240		1200		640		
	Color	B&W	Color	B&W	Color	B&W	
2. Number of Hours Requiring Prints	100 ①	140 + 20 hrs. of remedial instruction	120	1,080	235 ②	490	
3. Average Number of Images/Frames Required Per Instructional Hour	72	15	72	3	72	13	
4. Initial Production Requirement (2 x 3)	7,200	2,400 ③	8,640	3,240 ④	16,920	6,370	
5. Revision Requirement Per Year (10% of 4)	720	240	864	324	1,692	637	
6. Production Requirement (4 + 5)	7,920	2,640	9,504	3,564	18,612	7,007	
7. Number of Color Prints Required To Support 455 Hours of Instruction	7,920		9,504		18,612		36,036
8. Number of B&W Prints Required to Support the Remaining 1625 Hours of Instruction		2,640		3,564		7,007	13,211
9. TOTAL PRINT REQUIREMENT (Assuming a 2:1 Shooting Ratio)							72,072 Color 26,422 B&W

NOTES:
① Assumes 80 hours of primary instruction plus 20 hours of remedial instruction.
② This includes parallel presentations required for team training.
③ The required number of black and white prints is the amount required to suppor: the production of textual materials.
④ This is the number of textual illustration estimated to be required in addition to existing Tech. Orders and Manuals.

Table 12. Photographic Print Requirement

photo-plates for reproduction, and the preparation, processing and finishing of color prints. In the preparation of black and white prints, or photo plates, the primary tools of the photographic section will be the copy/process camera(s) and enlargers used to generate the original imagery to be converted into plates or prints for reproduction, printing and/or distribution. It is assumed that most black and white photography will be of graphics, line drawings, schematics, etc. For that percentage of the total black and white requirement which will require live action shots, a suitable combination of hand held cameras will adequately support a facility of this type. In generating the original black and white imagery at the process camera(s) from original graphic materials and line art, the selection of films will depend on the printing/enlarging requirements of particular photo/mechanical reproduction process to be used in printing textual materials. It will at least involve the use of orthochromatic or lithographic films designed primarily for making line and halftone negatives and positives.

The procedures for the exposure, processing, drying and finishing of black and white material will vary with the exact film used, its intended use, and the selected processing and drying techniques. Functionally, however, these procedures can be outlined as follows:

1. Expose original material. Depending on the nature of the material, this may be done as either a live action shot or copied from original graphics.

2. Process the exposed film. Since it is possible that at least four film sizes and two different types (roll and sheet) will require processing, the processing equipment and/or techniques selected must be capable of quickly handling each type of film. Because the exact volume of black and white work cannot be estimated, it will be assumed to be large enough to justify an automatic processor of the capacity of a Kodak VERSAMAT IIC or equivalent device. Roll film volume is seen as being light enough to be handled through manual processing, although a tube-type processor may be required to meet the processing time requirements of the facility.

3. Duplicate the negative(s). Depending on the anticipated use of the original imagery after processing, it may be used as is in the printing of a document or it may be printed to produce an enlarged or reduced duplicate that would in turn be used in the production of a text or Job Performance Aid.

4. Print the negative. The requirement for positive photo prints will vary according to the operating procedure for the facility. Manual processing of prints does not represent a cost effective alternative once the volume of prints reaches 50-100 per week. This volume is efficiently handled by an automatic print processor which, in addition to speeding processing time, allows more precise, consistent control of timing, temperature and replenishment.

The production of color prints to satisfy the requirement for a standardized input format for the generation of transparencies will require an extremely efficient and fairly large size color print operation. The functional requirements for a color print production facility of this magnitude would be as follows:

1. Expose Original Materials. The generation of color prints which are of suitable quality to serve as masters for the generation of transparencies requires particular care be given to the exposure, processing, enlarging and printing processes. Since the transparencies distributed to the training population will be at least two generations removed from the original imagery (original, print, and possibly internegative), extreme care in the composition, illumination, and exposure of the original shot is critical to the maintenance of acceptable quality in the successive generations. Most location photography will be accomplished with 35mm cameras to capitalize on the advantages offered by the equipment and films available in this format. The advantages offered by a range of quality lenses will allow the generation of quality color prints under location conditions.

Studio photography may require the use of larger format equipment to generate the largest image size possible under these special conditions.

However, as Smith (1968) has pointed out, it is the size of the image recorded on the film, rather than the overall size of the negative, that dictates the final image size.

Copy work for titles and graphic art, as well as for textual slides, would be restricted to the 8 x 10 image size during production or photographically reduced to that image size.

2. Process Color Materials. To process the amount of color film sufficient to support the required instruction it will be necessary to use automatic color processing equipment. The problem lies in selecting or acquiring an automatic color processor that will handle roll and sheet color film. Several of the medium capacity tube processors will handle both types of film, but are of less than ideal capacity for this application. The larger volume processors are of two types: they are either continuous roll film processors designed for motion picture film, or they are custom fabricated systems designed for extremely large photofinishers. In either case, they are not adequate for this application.

There are two alternatives that can satisfy the color roll film processing requirement of the facility. The first of these is to process the bulk of the film (using E-4 chemistry) in the continuous processor that will be part of the Transparency facility's continuous processing equipment, and acquire one tube type processor to serve the sheet film and small batch-roll film requirements. The second alternative is to install two or three tube processors that can be operated in parallel to handle large volumes of photographic input.

While the first alternative represents a cheaper per image processing cost, it does presume access to a continuous processor set up for chemistry appropriate to the origination film being used. Assuming these conditions are met, the first alternative represents the most cost effective approach.

3. Quality Control. With the negatives processed, the next step is printing. In order to achieve equivalent reflectance or transmission densities (thus achieving a higher probability of proper color balance and density in the final transparencies), each run of negatives (negatives from the same batch of emulsion, photographed at roughly the same time, under roughly the same conditions, and processed at the same time) would be preceded by a series of test strips which are exposed using the exposure meter of the printing system and processed. After processing, the test strips would be examined to determine the density, contrast and color corrections required. With these corrections incorporated, printing can proceed until an obvious change in negative characteristics or the beginning of the next run require another batch of tests to be performed.

4. Print Processing. The volume of color prints required, plus the normally allowed 5 to 15 percent safety factor in color printing, indicate that automatic color processing equipment is necessary. Maintaining standards of print quality and consistency would seem to require automatic print processing. The use of large volume automatic print processing equipment also precludes the requirement for separate drying equipment or facilities, since almost all automatic color print processors are dry to dry operations.

5. Print Finishing. The requirements for finishing in the color print facility are relatively minor technically, but are critical to the successful operation and reputation of the facility. After prints are removed from the dryer, they would be cut from the roll and sorted into batches corresponding to the grouped negatives routed from the print room. The prints would then be inspected and those failing to meet quality standards would be rerouted to the printing room for reprinting. When all prints in a given order (instructional sequence, lesson, etc.) are complete, then each print in an order and its associated negative(s) will be identified with a file number. These file numbers will form the basis for the photographic print file system which will be maintained by the print facility.

That file system will contain one copy of all prints as well as the negatives for all sequences. A copy of all prints will be sent to the instructional development team. This print will be the work print against which the team can check their scripts. The instructional development team will use the work prints to indicate to the photo section their requirements for labels and organizers to be added to the prints prior to copying.

When the instructional development team has completed their examination of the image portion of an instructional package, the work prints will be returned to the print facility for the addition of titles, graphic indicators, etc. These annotated file prints, as well as the artwork in a given set, will form the sources from which copies will be generated.

Based on the functional descriptions provided above, the types and level of costs associated with the operation of a photographic print facility can be identified. Table 12 and 13 summarize the requirements for photographic prints (both color and black and white) and the costs associated with their production. The cost breakdown in Table 13 assumes that the volume of black and white prints is one-quarter that for color prints. Labor and material costs were derived from the current price lists of several large photo-finishers and suppliers. The costs of the printing and processing equipment represent the manufacturers' cost of the equipment prorated over the volume of work shown in Table 12. This form of prorating equipment costs allows for viewing a possible worst case situation - equipment which is idle or even surplus after the baseline courses are provided with the estimated amount of media used.

Equipment Requirements

The specific equipment required to generate photographic prints is determined by both the volume and the application of the resultant prints. For convenience, all printing has been assumed to be from 35mm to a 6 1/4" x 9 3/8" image on 8 x 10 paper. As has been stated in the previous paragraphs, the generation of prints in this facility will have to be as rapid and as accurate a set of processes as possible. In order to insure that quality and speed of print production is maintained, it is recommended that a photographic print system be developed based on the automation of as many functions as possible. In order to implement that system, the following types of equipment are seen as required.

1. Cameras. Camera equipment required to generate the original negatives from which prints will be produced falls into two basic categories: (a) that required for location and studio photography and (b) that required for copywork. Cameras for location work will be 35mm cameras equipped with a complement of lens and accessories suitable for insuring the acquisition of the largest, crispest images possible in all situations. Studio photography for those images requiring special closeup treatment or special lighting should be photographed using equipment which will produce the largest image size possible. While the emphasis would be on 35mm, larger formats may be practical for certain applications.

2. Film Processing Equipment. In order to maintain consistent quality in the negative serving as the basis for the print generation process, it is required that some form of quantitative control of film processing be established and maintained. While the film manufacturers

	Color	B & W
Negative Origination Cost	$ 0.40 ②	$ 0.35
Printing Material Cost	$ 0.39 ③	$ 0.30
Test Materials Cost	$ 0.03	$ 0.02
Printing Labor Cost	$ 0.10	$ 0.10
Processing Labor Cost ①	$ 0.01	$ 0.01
Test Labor Cost	$ 0.03	$ 0.03
Recurring Cost Per Print	$ 0.96	$ 0.81
Initial Equipment Cost - Processing and Printing Equipment:		
Total	$ 8,000	$ 7,400
Per Print	$ 0.13	$ 0.48
Total Number of Prints Required (Table 3-1) + 20% Rejection/Reshoot Rate ④	86,486	31,824
Total Cost of Print Generation to Support 455 Hours of Individualized Instruction	$94,270	$41,052
Cost per Print ⑤	$ 1.09	$ 1.29

① Assumes automatic print processing equipment.

② Assumes Raw Material Cost x 10 for labor, etc. = Origination Cost.

③ Assumes high quality paper purchased in volume.

④ B & W print costs represent prints ready for half or continuous tone duplication.

⑤ The difference between color and B & W costs is primarily due to the amortization technique used for the printing and processing equipment; for the volume of black & white prints required equipment cost is higher on a per print basis. A higher volume of black & white print work would reduce the cost per print.

Table 13. Photographic Print Costs

have developed fairly exact chemistry for the development of their products, it is only when the requirements of each process step are kept within rather tight tolerances that the results are as consistent and valid as they should be. For the volume of color prints noted in Table 12, some form of continuous or large batch processing equipment would be required. This should be supplemented by at least one or perhaps two tube processors to meet small batch or short fuse requirements. Black and white print volume indicates that this requirement could probably be met with hand processing, but would probably be faster if a tube-type processor were used.

3. Printing Equipment. To serve the requirement for rapid and accurate generation of color prints requires an enlarging system which is capable of accurate and repeatable control of exposure conditions, including color correction. Black and white printing can be accomplished using less sophisticated enlarging equipment. To meet the requirements for volume production, to allow for a higher degree of consistency in print quality, and to reduce print costs, an easel system for the enlarger(s) designed to accommodate roll paper is seen as a desirable element in the printing system. The bulk loading of print paper allows actual printing of a negative to be accomplished in approximately 2 minutes.

4. Print Processing Equipment. Print processing by hand for the color print volume being considered here is possible, but certainly not reasonable. An automatic basket processor or continuous print processor seems a much more feasible and controllable approach to the problem. A continuous print processor is particularly worthy of consideration in the event that roll paper is used in the printing itself. Most continuous processors operate more efficiently with roll paper.

Facilities

The facility requirements for the photographic print function are roughly identical to those for the still-transparency facility requirements. The general functional spaces would be about the same size and, if the photo print facility were an independent operation, it would require at least as much space. Assuming that the transparency facility and the print facility are colocated, semi-autonomous organizations, sharing certain common facilities would allow the space requirements of the print facility to decrease by about one-third through the shared use of studio, color film processing, color printing, chemical storage, and finishing spaces. Specific service, air conditioning and ventilation requirements would be approximately the same in both types of facilities.

Motion Picture Facility

The established value of motion pictures as instructional tools and transmission devices for information pertaining to the dynamic nature of tasks, operations and procedures warrant their inclusion in any system of individualized instruction. The question to be addressed here is the design of a motion picture capability to support the development, production and distribution of motion pictures for instructional purposes. The recommendation was made that the Super 8mm format with magnetic sound be adopted. In keeping with that recommendation, the motion picture facility, equipment and capabilities described below are intended to support the origination, processing and duplication of Super 8 footage.

Staffing

In order to assess the staffing requirement for the motion picture facility, it is necessary that the production volume of the facility be established. In Table 14, the estimated hours of mediated instruction for each of the baseline courses is shown. If it is assumed that one-tenth of that amount would be supported either directly or for enrichment or remedial purposes by motion picture imagery, then we have a basis upon which to estimate motion picture facility staffing requirements. This estimate of 50 hours is by itself insufficient data on which to base production and staffing requirements. The extent to which an hour of instruction is supported by a motion picture segment is a function of its intended utilization. Is it intended to be the primary source of information, or is it to serve as supplemental, enrichment or remediation for material presented via another medium?

The exact requirement for motion picture footage to support instruction cannot be established without an intensive analysis of each individual lesson in each course. This level of analysis has not been performed as a part of this study. However, based on the analysis that has been performed, some estimates can be made to serve as guides in sizing the staffing, equipment, and facilities requirements.

As stated above, we have hypothesized that 50 hours of instruction (spread across the three courses) will be supported by motion picture footage. In those 50 hours we will assume a three to one mix between motion pictures as a supplementary source of instruction and motion pictures as the primary source of instruction. Thus, in every instance where we use motion pictures as the primary source of instructional information, there are assumed to be three other applications in which motion picture sequences are used for supplemental, enrichment, or remediation.

When used as the primary mode of instruction, motion picture sequences are assumed to require 15 minutes running time out of each hour of instruction. Supplementary applications are assumed to require an equal amount (15 minutes) of running time per hour to be supported.

Inventory Management Course	
Total Hours in Course = 240	
Hours to be Converted to Mediated Instruction	100
Revision Requirement per Year = 10%	10
Total	110
Number of Hours to be Supported by Motion Pictures (10% of Total) =	11
Precision Measurement Equipment	
Total Hours in Course = 1200	
Hours to be Converted to Mediated Instruction	120
Revision Requirement per Year = 10%	12
Total	132
Number of Hours to be Supported by Motion Pictures (10% of Total) =	13
Weapons Mechanic	
Total Hours in Course = 640	
Hours to be Converted to Mediated Instruction	235
Revision Requirement per Year = 10%	24
Total	259
Number of Hours to be Supported by Motion Pictures (10% of Total) =	26
TOTAL Number of Hours to be Supported =	50

Table 14. Motion Picture Baseline

Using the 50 hour figure derived in Table 14 and the assumptions stated above, the required amount of motion picture film footage would be 12.5 hours. The largest percentage of this footage would be in the form of single concept films.

The functional break out of responsibility for the production of this volume of motion picture footage requires the following capabilities: (These capabilities probably represent different individuals, but they do not represent any attempt at sizing the number of manhours required.)

Scriptwriter. Working from the instructional objectives, or ideally from the storyboard developed by the instructional materials developer, the script writer would prepare both shooting and dialogue scripts as required.

Cinematographer. The motion picture photographer required here would have to be more than a cameraman. Because of the relative low volume of actual shooting time, this individual would also have to serve other functions and would most probably serve as his own lighting specialist and editor.

Soundman. To service the requirements for sound recording and editing will require the services of an experienced audio technician. The requirement for his services is not sufficient to warrant employment of a fulltime audio technician. However, since these same skills and capabilities are required in the production of audio-instructional materials, it is quite likely that the required capabilities/individual(s) could be time shared with the audio instruction production facility.

Editor. In order to permit the logical development of the storyline, clean transitions between different shots, and coherent integration of sound and visuals, the services are required of an individual who can perform the editing function. As was suggested above, this might be a logical extension of the cinematographer's role in the facility.

Processing Specialist. This function will be responsible for processing original footage, producing work prints (if required), printing the footage resulting from the editing process, and the printing and processing of the required number of duplicate copies.

Motion Picture Preparation

The sequential processes of motion picture production, processing, editing, duplication and distribution are functionally simple and straightforward. However, the choice of approaches and equipment for the generation of motion picture footage to support individualized instruction is governed by a host of technological and more subjective factors which must be considered prior to actual production.

The functional steps to be accomplished in the production of instructional Super 8mm films are listed below:

1. Script Preparation. The filming or shooting script will include the narrative text, any dialogue required and, most important, directions as to the type of imagery required, the types of shots to be made, the various camera directions,camera locations and lighting. The shooting script can only be generated from a complete script or story board developed to convey a specific set of information. The preparation of shooting scripts is a task for an experienced script writer/director who has familiarized himself with the material to be covered and the objectives to be met by the presentation.

2. Production. Production represents the process of actually recording the desired material on film. Prior to actual filming, a large amount of preparation must be accomplished. The amount of preparation and the thoroughness with which it is accomplished is governed by what is to be produced. The research on motion picture films has never succeeded in identifying those characteristics which distinguish good productions from bad ones.

One of the advantages of the Super 8mm format is that its relatively low cost allows the development of prototypes that can be tried and evaluated. These prototype materials can be developed in several different ways. For this facility the following techniques are recommended as equally useful alternatives for prototype development. The techniques are for the generation of prototype visual materials.

The simplest technique is for the cameraman or script developer to walk through the proposed script with the originator and/or competent instructor and use a point and shoot camera (still or motion picture) to record, in the sequential order of the script or storyboard, imagery approximating that required for the actual production. This footage can then be processed and reviewed by the principals involved. Depending on the sophistication and experience of the individual using the camera, the result of this effort may be of high enough quality to serve as a prototype for presentation to students for formative evaluation.

This technique is extremely effective in recording the factual aspects of such things as sequence of operation, object placement, camera angle, type of shot, etc., but it allows only a small degree of flexibility in the use of optical and special effects which may be critical to the impact and effectiveness of a given film sequence.

An alternative technique that achieves results that are equally impressive (because of its speed and flexibility) is the use of a video-tape system to record and playback the material being considered for inclusion in the motion picture production (Smith, 1971). This technique is particularly useful when a portable VTR system can be taken to the source of the action and both the sight and sounds to be included in the final production are recorded. Through properly sequenced recording, a prototype containing the desired imagery, sound effects, dialogue and the editorial comments of the originator are contained in a single record ready for immediate replay.

Either of the techniques described above is suitable for the development of prototype materials to be viewed by individuals directly associated with the development of the instructional package and to a limited sample of students for validation.

There are presently four techniques available for the preparation of original motion picture footage intended for distribution as Super 8mm. These four techniques are: (a) super 8mm origination with the camera original serving as the distribution copy, (b) 16mm origination and reduction printing to Super 8, (c) video tape origination, 16mm kinescope and reduction printing to super 8, and (d) super 8mm origination, with duplicates optically or contact printed. Each of these is distinguished by certain advantages and disadvantages whose weighting may change as a function of base capability, equipment availability, etc.

Alternative 1) (Super 8mm origination and display) is the least costly method of producing and displaying a single copy of a movie presentation.

Alternative 2) (16mm origination), requires the same equipment and personnel presently used by the Air Force to produce its training and promotional films. The generation of Super 8mm imagery in this way requires that when duplicates of the 16mm finished product are printed, they be printed on an optical reduction printer as Super 8 rather than 16mm release prints.

Alternative 3) (video origination) can be done in several different ways - in the studio using broadcast quality equipment or with portable equipment at specific locations. Production of Super 8 release prints from a video tape or live video presentation will require, with presently available kinescope equipment, two separate transfers - from video to 16mm and then from 16mm to Super 8 via an optical reduction printer.

Presently available kinescope equipment is designed for the generation of 16mm footage. While it is possible that Super 8mm kinescope equipment will become available, there is none available now. Thus, the production of Super 8mm prints using this method means that the print will be at least two generations removed from the origination medium, with the associated reduction in overall image quality.

The introduction of Electron Beam Recording (EBR) equipment, by which electronic imagery is imprinted directly on the film, offers the potential for direct production of Super 8 internegatives or 16mm internegatives which can then be printed without the loss of quality inherent in the video tape to film transfer process.

Alternative 4) (origination on Super 8mm film) is presently feasible and quite practical for the type of instructional application being considered here. Using top quality Super 8mm camera equipment or 16mm cameras modified to use double stranded Super 8mm film and exercising the same care and attention to detail which characterize any motion picture production effort, it is presently possible to generate Super 8mm footage which is virtually indistinguishable from 16mm footage of the same subject. The use of Super 8 as the origination format does mean, however, that all fades, dissolves and other special effects desired in the sequence will have to occur in the camera, since it presently is impossible to obtain accurate special effects during the editing of Super 8 or for that matter, even to perform editing in the same sense that the term is applied to 16mm or 35mm motion picture work. With proper planning and experience, the use of Super 8 as origination footage for short presentations and single-concept films will result in quality instructional material at a far lower cost than would be possible using 16mm as the originating format and then duping down to Super 8.

Sound recording for all of the alternatives described above would be accomplished in the same manner. Editing voice over narration onto either 16mm or Super 8mm original footage or work prints is a task for a highly qualified audio technician using magnetic transfer equipment. Once the work print master or answer print has been completed with the sound track, the next step in the process is the production and processing of the required number of copies.

The equipment and material requirements for the origination of Super 8mm motion picture film are shown in Table 15.

3. Processing. The processing of 16mm film in the volume discussed in preceding sections does not pose any problems for the Technical Training Center at Lowry AFB. That volume could easily be accommodated by the present 16mm processing facilities available within the base. The volume is too small to justify the acquisition of a continuous film processor solely for the motion picture facility. If, however, one considers the requirements of the still-transparency facility for processing large volumes of 16mm and/or 35mm footage, then a continuous processor shared by both facilities is certainly a cost-effective answer to processing.

4. Printing. After editing is completed and approval of the answer print has been obtained, then the printing of the required number of duplicates can begin. If the printing master is 16mm, then it must be optically printed on a reduction printer to produce the required number of Super 8 release prints. This printing can be accomplished either on a one to one, one to two or one to four ratio between master print and release print. While the one to two and one to four reduction printers would accomplish the required printing tasks much more efficiently than a one to one optical printer, the latter is favored for three reasons.

1.		**Equipment Requirements**	Cost
	a)	Cameras	
		1 - Arriflex S camera (or equivalent) with associated lenses, magazines and carrying cases.	$ 7,000
		and/or	
		1 - Canon Scoopic 8 or Beaulieu Super-8 with associated lenses, magazines and carrying cases	$ 3,000
		2 - Canon Model 1218 or Bauer Crown Royal	$ 1,400
		and/or	
		2 - Kodak Model XL	$ 300
		TOTAL	$ 11,700
	b)	Cinematography Equipment	
		2 - Tripods, Fluid heads	$ 900
		1 - Pentax Spotmeter	$ 120
		1 - Colortran meter and filters	$ 125
		2 sets Filters (1 for 16 mm and 1 for 8 mm primary cameras)	$ 240
		1 - Portable Light System	$ 3,000
		1 - Studio Lighting System (including dimmers)	$ 6,000
		- Cases to accommodate above equipment	$ 400
		- Miscellaneous accessories	$ 200
		TOTAL	$ 10,985
	c)	Sound Equipment	
		1 - Uher 4000-S Tape Recorder, accessories and auxiliary mixer	$ 800
		1 - Sony wireless microphone system	$ 450
		1 - Audio control system, incl. Mixer, and controllers	$ 300
		2 - Lavalier Microphones	$ 138
		2 - Cardioid Microphones	$ 500
		1 - Unidirectional Microphone	$ 255
		Miscellaneous Microphone Stands and Cases	$ 200
		1 - Microphone Broom Stand	$ 55
		TOTAL	$ 2,698
	d)	Processing and Printing Equipment	
		1 - Continuous Film Processor for 16 mm film (Cintel Model LTM-ME4, Sickles Automatic Film Processor, Bell and Howell 036204 or equivalent)	$ 10,000
		1 - High Speed Optical Reduction Printer (ACEM or equivalent)	$ 20,000
		1 - MAG Striping Unit	$ 6,000
		TOTAL	$ 36,000
	e)	Associated Equipment (Including Editing and Cleaning Equipment).	$ 6,000
		GRAND TOTAL	$ 67,383

Table 15. COST DATA ASSOCIATED WITH MOTION PICTURE PREPARATION AND DISTRIBUTION

The first is that the demand placed on a one to one optical printer by this facility does not approximate the capacity of the device. Secondly, the flexibility inherent in a high-speed optical printer capable of handling 35, 16, and Super 8 reduction and blow-up printing for both the still-transparency and the motion picture facilities would be extremely desirable. The third reason is that the availability of an optical printer capable of reduction or blow-up printing adds another dimension to the motion picture facilities capability. Super 8 originating footage can be blown up to produce a 16mm internegative. The subsequent internegative can be edited and the result can then be printed as Super 8 release prints. This intermediate step in production of Super 8 footage was not mentioned earlier, because it is only feasible and cost effective with the availability of a high speed optical printer.

As was pointed out in this report, the use of a high speed optical printer improves the capabilities of both the still-transparency and motion picture facilities and would also improve the cost per copy ratio in both facilities by allowing the initial costs of the printer to be prorated across the two facilities. (It should be noted that the volume of motion picture production required in support of the three baseline courses is not enough to warrant the establishment of an independent facility with the production, processing and printing capability for motion picture footage unless there is an integration of equipment and other facility requirements between media and a commitment to expand to other courses.)

Release prints would be processed in the same manner as described on page 165 with the additional step of lubricating the film. There are a number of surface coating treatments available as well as several vacuum film treatments. All of these can be added to the recommended types of continuous processors prior to film winding. While slightly more costly, the vacuum-type treatments appear to be somewhat more effective and probably constitute the best solution to the problem.

After processing, Super 8mm release prints should have magnetic striping applied to the base side of the film. Presently Super 8mm film stocks are not available in prestriped form. The two magnetic stripes (recording and balance) can be applied locally or can be obtained from commercial sources. Striping is available from commercial sources at $.06 per foot. The production volume anticipated for the motion picture facility may not justify the procurement and operation of a magnetic stripe applicator in the face of this level of commercial cost.

5. Packaging. The characteristics and utility of alternative packaging concepts for Super 8 motion picture film were described previously. To recapitulate briefly - at present the selection of particular projection equipment defines the packaging concept to be used or vice-versa. The three available categories are reel to reel, cartridge and cassette. Of the three, the cassette is technically the most attractive for our application.

Reel-to-reel projectors for Super 8 are similar in design and construction to 16mm motion picture projectors. They are characterized by their vertical orientation and presence of the film and take-up reels. Reel-to-reel projectors in the Super 8 format accept standard reels which are interchangeable between different makes and models of projectors.

Cartridge loaded Super 8mm film is spliced into a continuous loop and packaged in a combination storage/projection cartridge. Cartridges for any one manufacturer's equipment are not interchangeable with those of other manufacturers. Super 8 cartridges, particularly the Fairchild Moviepak, are specifically designed for a family of stand-alone devices.

Cassettes are presently available in three forms: Eastman-Kodak, Bell and Howell and Bolex. All have non-compatible cartridge systems on the market. The Eastman system has been adapted by several other manufacturers. Functionally, cassettes operate in the same manner as reel-to-reel systems, the difference being that the film reel is contained within the cassette and the take-up reel is usually internal to the projector. Presently available cassette projectors incorporate a host of features which enhance their instructional utility. This includes such features as automatic rewind and built-in reviewing of selected film segments.

From the packaging function standpoint, the reel-to-reel concept is the easiest and least expensive of the three approaches. The film is simply wound off the processing spool, cut, clipped or banded to prevent unspooling, boxed, and labeled. The cassette system, however, is almost as simple and is possibly even less expensive overall. To load a cassette, the film is wound off the processing spool, cut, leadered and clipped (in such a way as to prevent the tail of the film from leaving the spool), and dropped into the cartridge and labeled. Cartridge loading represents both a more time consuming and complex process. The required footage is wound off the processing spool but instead of being wound on a double flanged reel, the film is wound around a spool or hub in such a fashion that both ends of the film are accessible (in practice this spool or hub is the bottom half of the cartridge). These two ends are spliced together to form a single loop of film. After splicing, the film loop is inserted into the cartridge. The exact placement of the film, the size of the loop through the gates of the cartridge and the amount of tension on that loop are critical to the successful functioning of the cartridge system. Cartridge loading is sufficiently expensive in terms of labor dollars that the Air Force Audio-Visual Information Service (AAVS) still allows commercial laboratories to load their cartridges as a less costly alternative to hiring, training, and maintaining enough personnel to service its cartridge loading requirements.

The packaging concept selected will also determine the requirements for additional protective materials (boxes, wrappers, etc.) and the amount of identifying labels required, e.g., both cartridges and cassettes can serve as their own packaging and only a single label is required for each package versus two for the reel and box concept.

After packaging, each set of duplicate films would be conveyed to the instructional materials development, planning and control representative for that particular instructional package or directly to the responsible training supervisor.

Facilities Requirements

1. Space Requirements. The area required for the motion-picture capability described on the previous pages is contingent on two factors: (a) the amount of studio shooting versus location footage, and (b) the extent to which studio, processing and printing requirements can be shared between the Still-Visual, Video and Motion Picture functions of the instructional media production organization. If the continuous film processor and high speed optical printer are located in the still-transparency facility, and the largest percentage of footage to be shot will be on location with the video studio serving both for video and motion picture production, then the space requirements for the motion picture facility are reduced to about 600 square feet to serve as offices for the scriptwriter(s) and cinematographer, administrative and film file space, editing room, and equipment storage and maintenance areas.

2. Service Requirements. Normal electrical, ventilation and air conditioning services for office spaces are all that will be required.

Microform Facility

The introduction of microform into training poses no fundamental physical or psychological barriers to students. Grausnick (1970), among others, has shown that the communication of narrative information via microform is both technically and instructionally feasible. As was pointed out in this report, there is a requirement within the three baseline courses for some type of microform system to serve the information retrieval requirements, and certain specific instructional functions as well. The analysis performed also indicated a slight edge for microfiche over other microforms with respect to their applicability to the individualized technical training environment. The benefits accruing to the use of microform are seen as:

Space Savings. The storage requirements for microfiche is several orders of magnitude less than that required to store equivalent amounts of textual material.

Quicker Dissemination

Faster Retrieval. With either manual or automatic retrieval systems, access to a specific page of information is quickly accomplished.

Lower Cost Distribution. Since the volume and weight of microfiche is considerably less than an equivalent amount of paper materials, shipping and packaging costs are significantly reduced.

Reduced Production Costs. The cost of producing microfiche originals and duplicates tends to run only 10% to 15% of the cost for equivalent volumes of conventionally printed material.

In order to capitalize on these characteristics, it is assumed that microfiche will be used to serve two purposes in the learning environments developed during this study. These will be:

1. For the storage distribution and display of reference data such as manufacturers specification data, subsystem tech orders, federal stock number lists, etc.

2. As the distribution and display medium for prototype printed material.

The first application is relatively obvious and is merely the implementation of presently available microform technology to areas within the baseline courses which correspond very closely to areas already benefiting from the use of microfilm. The second application is somewhat unique, capitalizing on the lower production and distribution costs inherent in microfiche production as well as on the quicker production times possible with microfiche. Prototype textual and other instructional materials intended for final production as texts or workbooks can be produced as microfiche. The use of microfiche for draft material production and distribution will permit lower costs and more rapid dissemination than the use of paper text. This means that both formative and summative evaluations of textual and/or graphic instructional materials can be conducted rapidly and that alternative presentation techniques or content can be introduced and evaluated much more rapidly than would be possible using conventional paper based reproduction systems.

Staffing

Because of the degree of automation inherent in presently available microfiche production equipment, and the rapidity of the processes themselves, only a small staff will be required to operate a facility capable of servicing the instructional and reference requirements of the three baseline courses. At minimum, two people would be needed, however, it would probably be more adequately staffed by three individuals. The functional capabilities required to adequately staff the microfiche production facility are:

Camera operation. The camera operator would be responsible for camera system operation and maintenance.

Processing. Some films used for the production of camera originals and printing masters are capable of hand-processing. Most high resolution film used for these applications is designed for automatic processing. The processing specialist must be capable of adapting to both situations.

Production. This function would involve the duplication of microfiche, packaging, organizing and labeling.

If a staff of three is assigned to this facility, the suggested distribution would be one individual as the camera operator with the other two staff members sharing equal responsibility for the latter two functions.

Microfiche Preparation

Microfiche preparation will begin upon receipt of the printed and/or graphic materials from the author(s) or the instructional development group. The first step in the production cycle is the preparation of a camera original (a transparency, in some form, of the printed material). This transparency is exposed directly in the camera. The optimal camera system for this application would be a 16mm microfilm camera. The output (camera original) from this type of camera would be a roll of 16mm film which is processed and then cut to yield a length of film containing one or more documents with the images in the exact order they were photographed. An alternative approach would be to use a 105mm step and repeat camera (the output would be a 4 x 6 fiche). In order to minimize the difficulty of material revision and to enhance the efficiency of this application, the 16mm system appears to be a more efficient solution.

1. Microfilm Processing. Camera original microfilm is identical in construction and very similar in composition to equivalent format motion picture films. The significant differences between microfilm and regular motion picture film lie in the resolving power (ability of a photographic emulsion to record detail). Generally speaking, microfilm emulsions have higher contrast and resolving power than films intended for other photographic purposes. Color emulsions used for microfilm work are characterized by their high resolving power and relatively low exposure values.

Aside from these characteristics, photographic film designated as "Microfilm" is identical to other photographic film of the same size and is processed in a similar manner. In order to retain the resolution and granularity characteristics at a desireable level, differential processing times and minor but significant variations in process chemistry are required.

For this application, the 16mm camera original film volume will be sufficient to warrant the acquisition of a medium volume (5 to 20 feet per minute) continuous flow processor, specifically designed for black and white microfilm processing. Color microfilm will constitute only a limited proportion of the total volume of microfilm production and will not require a processing capability to handle the volume of material that will be produced in black and white. Rather than providing for color processing within the microform facility, it is recommended that color microfilm be selected that can be processed as Ektachrome or Kodachrome. Suitable chemicals and processors will be available in the motion picture and/or the still-visual facilities of the media development facility.

Continuous flow processing equipment for microfilm is similar in construction and functioning to continuous flow processors for other film types. The differences that can be discerned between the two types of processors are the chemistry involved and the size and cost of the units. Smaller and lower cost units are available for microfilm processing and are already available at Lowry Air Force Base.

2. Microfiche Duplication. Upon completion of processing, the camera original film will be edited into lengths equivalent to each document or instructional module. These lengths will in turn be cut into strips equivalent to the row structure of the selected fiche format and inserted into an acetate jacket. The jacket-fiche is the printing master from which duplicate fiche will be generated. It will also serve as the master file copy for that document. As changes, revisions, etc. are required in a given batch of instructional materials, the master fiche can have specific pages or whole sections changed without disturbing the integrity of the remaining images of the master.

This may be accomplished by photographing only the rows containing changed pages, processing that film, and then removing the voided pages and inserting the changed rows in the printing master.

To produce the required number of duplicate fiche for actual distribution to students will require the use of a microfiche duplicator. Three types of duplication systems are available for microfiche duplication, these are:

Photographic. This is essentially an optical printer using 105mm film as the print/release medium. The jacket/fiche would be exposed under a camera containing 105mm photographic film which would be processed and then cut to size. Essentially, each frame exposed by this camera is a 4 x 6 fiche.

Diazo. Diazo duplication is similar to the photographic process with the exception that processing is by exposure of the copy stock to ammonia either in gaseous or liquid form. The advantages of Dizao duplication are the rapid processing time (seconds) and the low cost of the film stock.

Vesicular. Vesicular duplication involves the use of Kalvar or other thermal sensitive films to produce the duplicate. The film is exposed similarly as described in the two preceding paragraphs, but there is dry processing which involves exposure of the film to a thermal source.

For this application, Diazo duplication seems to represent both a technically and cost-effective approach to the rapid production of duplicate fiche in the volume required. An automatic duplicator capable of 300 to 400 copies per hour would be adequate for peak loads and still be cost-effective for lower volume runs.

3. Fiche Packaging. No special packaging is required for those fiche intended for distribution to and use by students other than some type of packaging which allows related fiche to be stored together. Simple envelopes or paper pockets are adequate for this task.

Depending on the type and/or specific model of information retrieval and display system selected to support the baseline course, there will be the requirement to package, code, and index each individual fiche in the system. The extent to which this will be required, and the exact nature of the tasks involved, cannot be determined until a specific information retrieval system is selected.

Facilities

The space requirements for the microform production function would be approximately 400 square feet. No special layout of this space is required, although it would be advantageous if the space occupied by the camera could be separated from the rest of the facility's operations.

Services

Normal electrical, ventilation and air conditioning services required for office spaces will be required. The space will require plumbing and drain lines to supply the processing equipment.

Equipment Requirements

Table 16 is a listing of the equipment required for the microform facility.

	Cost
1. Camera	
1 - 16mm microfilm camera accepting 100 ft. reels, capable of photographing imagery up to 24" by 36" at a 24 to 1 reduction ratio.	$ 4,000
2. Processor	
1 - 16mm continuous flow film processor, designed to produce archival quality microfilm using conventional processing. Capable of processing 5-20 ft. per min.	$ 6,000
3. Duplicator	
1 - Microfiche diazo duplicator capable of 300-400 duplicates per hour, processor could be integral to the printer.	$ 5,000
4. Miscellaneous	
1 - 16mm editor	$ 200
1 - Color Densitometer	$ 2,500
1 - Reader/Printer	$ 2,000
Miscellaneous cutting, storage, quality control equipment, etc.	$ 1,000
Total	$20,700

Table 16. Microform Facility Equipment

Video Production Facility

In describing the requirements for the video production facility, the following rationale has been established.

Video will be used in three ways within this instructional system:

1. It will be used to assist in the training and evaluation of team tasks.

2. It will be used to assist in development of instructional materials for all three courses, and

3. It will be used as a production medium for the development and display of prototype materials.

Taking each of these applications in turn, we can establish their impact on the configuration of the video facility.

The first application, to assist in the evaluation and training of team tasks, is predicated on the assumption that instruction in motor or psychomotor behavior proceeds better when the student(s) are provided a model of the behaviors they are to master. This performance model should be available for reference during the instructional process. Recording the student(s) performance (preferably just one individual's role at a time) and then comparing it with the model will allow the student to note his own deficiencies. This technique for providing feedback to the student is seen as particularly effective in the weapons mechanic course from Block V on, provided that appropriate camera systems can be developed which are both unobtrusive, reliable and accurate enough for the demands inherent to the proposed application. Given that such a system is developed, the role of the video facility would be limited to the installation and maintenance of the equipment after installation.

The second application will involve the use of portable and studio VTR equipment to assist the development of individualized instructional materials. Smith (1971) has proposed that VTR equipment can be employed effectively and economically during instructional development.

"Current off-the-shelf equipment can be used for data gathering during the analysis of system requirements. It can be very advantageous in obtaining clear and concise definition of training requirements. This same equipment can be employed for initial development of the course objectives and the test materials. During this phase it has proven particularly beneficial in revealing enabling objectives that might otherwise be overlooked, developing a logical presentation without extraneous material, establishing definable objectives, and encouraging the inclusion of self-evaluation and confirmation as an integral part of the learning process. During the development and validation stages, the equipment can be used for initial scripting, for editing and re-editing, for obtaining content approval, and for individual tryout by students. During these activities, video enables the development of material through the evolution of many revisions prepared quickly and easily with a minimum of interference in the developmental activity by delays due to requirements for outside technical assistance. Finally, the techniques enable the course writers to obtain a viewable end product before they have to commit themselves on the media to be used. The video tapes can then be used as the draft or shooting script for the development of the manual, motion picture, or prenarrated slide sequence. The major criterion is that equipment be available that can be used by system designers with a minimum of interruption of their creative endeavors. While it is recommended that video recordings be used during the development of training sequences, it is not advocated that they be used for presentations in the classroom. Rather, conversion of the training material to manuals, prenarrated slide sequences, or movies is advocated."

The video facility described in the following paragraphs would support this application by providing the equipment, training and, if necessary, the personnel to actually video tape the instructional development phases.

The third application, the use of video as a development medium for instructional materials, is predicated on the capability of video tape to serve as a versatile, rapidly modified format which is capable of almost instantaneous review and revision. Material developed as video may be displayed as video or converted to other media. Suport for these applications will constitute the bulk of the video facility's staffing, equipment and space requirements.

Staffing

The staffing requirement for the video production facility is based on the assumptions expressed above. The major emphasis in staffing is placed on the technical, rather than the production, capabilities of the staff. In the previous sections of this report we have expressed our staffing requirements as a function of the volume of material to be produced by the facility. In estimating the staffing requirement for the video facility, such an approach will not provide an accurate baseline for identifying either staff functions or numbers. Functional allocation of staff responsibilities within the video facility would require the following types of personnel:

Scriptwriter. Working from instructional objectives, or ideally from the storyboard developed by the instructional materials development team, the scriptwriter would prepare shooting and dialogue scripts as required. Functionally, the tasks of the video scriptwriter are identical to those of the motion picture scriptwriter. Operationally, the differences in production technique require different approaches to script development. While it is possible that the responsibility for script development could be shared between the two facilities, it is more reasonable that these tasks would be performed by separate individuals.

Director/Production Coordinator. Responsibility for all aspects of video production will rest with this function. Depending on the final volume of material to be produced as finished video, this may be one or more individuals. Functionally, the director will be responsible for obtaining a satisfactory script, procuring all required graphics, determining location and on-camera personnel requirements, and actual direction of taping activities.

Production Specialist. The primary responsibility of this function will be the operation of all video equipment and systems within the facility. In accordance with the three applications described previously, a substantial percentage of the video facility's effort will be expended in the development, implementation, and maintenance of closed circuit or VTR systems within the baseline courses. The production specialist would be responsible for design, equipment selection, and training of instructional personnel in the use and operation of video equipment for evaluation and instructional development applications.

In addition to these responsibilities, the production specialist would be responsible for video console operation, lighting, and possibly even audio during the production of instructional tapes. The production specialist would also take responsibility for post-production activities including editing, addition of narration or second language, preparation of kinescope recordings, etc.

Camera Operator. In the production of instructional video tapes, one or more camera operators will be required to perform various tasks associated with the tape production. The degree of automation built into the production facility and the competency of the production specialist would determine both the number of operators and the skill level required to adequately staff the facility.

Soundman. While audio recording for video is slightly less complex than that required for motion pictures, it can still benefit from the services of a qualified audio technician. Since the volume of video tape production will not warrant an audio technician being assigned to the video facility, it is suggested that support be obtained on an as required basis from the audio facility.

Maintenance Technician. In order to maintain the video equipment complement of the facility and to insure the proper functioning of the video equipment provided to the instructional departments, services will be required of a video systems technician who is capable of maintaining camera, switching, and recording equipment.

Video Presentation Preparation

The development of video presentations to support individualized technical training must be considered in terms of the three applications described previously. In general terms, the process is the same, however, the specific approaches and equipment required for each application will differ.

1. Evaluative Video Application. In a sense, no "presentations" will be prepared for this application of video to the instructional process. Rather, a video system will be assembled, installed and applied to the evaluation of complex psychomotor and/or team training task performance. Our analysis indicates that the instructional events which would benefit most from the application of video recording techniques would be similar to those in weapons mechanic training. In those events and training sequences where the instructional strategy employed is to confront the student with operational or near operational tasks and then to critique his performance, video recording can assist by recording student performance.

For these applications and similar types of training, the video facility would design, install and maintain single or multiple camera/recorder systems which are capable of fully automatic or instructor control. These systems would consist of a camera(s) mounted in a fixed (or remotely controlled) position(s), a simple recorder/player, and one or more monitors. In use, the instructor would activate the system at the beginning of a sequence and then observe student performance directly or on a monitor. Depending on the degree of control he is afforded, the instructor may or may not direct the camera(s) to isolate specific performance factors. After a task sequence is completed, the instructor would replay the taped sequence and use it to direct the student's attention to specific errors or to highlight exceptionally good performance. Slow, still frame and speeded viewing capability is highly desirable for this application.

2. Instructional Systems Development Using Video. The detailed application of protable video equipment to instructional systems development is covered in a report prepared by Smith, 1971.
To support this application, the video facility would provide the required portable video and playback equipment, train instructional development personnel in video system operation and techniques, and maintain and service all portable and playback equipment required for this application.

3. Video Production. Video production capability within this facility would be aimed primarily at the development of prototype instructional materials that would either be reshot on film or prepared as a kinescope of the videotape. This emphasis on the role of video as a production rather than as a distribution medium is deliberate, and is predicated on the disparity in the equipment and storage/display medium costs between film and video tape. The equipment required to support the development of complete video productions comparable in quality to the standards established for Super 8mm motion pictures and filmstrip presentations is listed in Table 17. The volume and capacity of equipment listed is predicated on a production volume of 50 hours. This is the same amount of production allocated for motion pictures and is in actuality the same block of time. The assumption operating here is that the largest extent of video production would be in support or in lieu of motion picture production.

Video production in support of individualized technical training would be accomplished using equipment designed specifically for instructional and commercial applications as opposed to broadcast applications. The primary impact of this decision is an order of magnitude reduction in cost for the facility's equipment and an emphasis on 1/2 inch video tape equipment. The equipment complement shown in Table 17 would adequately support the production of 50 hours of instructional material, as well as the requirements of applications one and two as listed above.

4. Post-Production. The post-production phases of video tape preparation are analogous to the editing and processing functions in motion picture production. Using the equipment listed in Table 17, the amount of post-production for a given production should be minimal, with two exceptions. The first of these exceptions would be the preparation of tapes that include sequences taped in different locations, at different times or on any but the master tape.

The combination of these discrete video sequences will require a system capable of interfacing several different sources and synchronizing them during preparation of the master video tape (this is the function of Image Enhancement Equipment listed in Table 17).

The second exception would be in the conversion of video taped materials onto film.

5. Packaging. As stated above, one-half inch video tape will be both the production and distribution format for the video facility. However, most, if not all, of the video tape produced will be converted to Super 8mm film footage for distribution and use in individualized instruction. At the present time, this would require the use of a 16mm kinescope recorder, processing of the 16mm footage, and then using an optical reduction printer to produce the required Super 8mm copies. This process would be simplified by the use of either a Super 8mm kinescope system or an Electron Beam Recording (EBR) system. There are no Super 8mm kinescope systems available and EBR for tape or live video to film transfer has only just been introduced to the technical community.

Facilities Requirements

1. Space Requirements. The area required for the video applications described on the previous pages is approximately 1200 square feet, divided into 3 major functional reas: (a) maintenance and equipment storage, (b) post-production, and (c) studio. The kinescope recording equipment and the film and tape storage for the facility would be located in the post-production area.

Table 17. Video Equipment List

a) Portable Equipment

6 - Portable Compact Battery Powered Recorder/Players capable of recording and playing back both video and audio simultaneously or separately. Recording pattern would conform to EIAJ Type I standards. The recorders shall be capable of better than 300 lines horizontal resolution with a video signal-to-noise ratio of at least 40 dB. (Sony Model AV3400 or equivalent)	$ 8, 400
6 - Video Cameras: 2/3" separate mesh vidican tube capable of at least 400 lines of horizontal resolution with a video signal-to-noise ratio of at least 40 dB. Automatic Iris capable of adjusting from 30 to 10, 000 foot-candles 5 to 1 Zoom lens and built-in viewfinder. (Sony AVC-3400 or equivalent)	
6 - Condensor Microphones (may be incorporated in camera).	
6 - 9 inch (diagonal) Video Monitors	$ 1, 800
Total	$10, 200

b) Evaluative Video Equipment

2 - Video Recorder/Players, EIAJ Type I, 1/2 inch format. Units are to be capable of recording or playing back audio or video separately or simultaneously with a horizontal resolution of more than 300 lines and a signal-to-noise ratio of at least 40 dB. Both audio and video record levels shall be capable of automatic or manual control. (Sony AV36[illegible], Panasonic NV3020 or equivalent).	$1, 400
4 - 2/3" Separate Mesh Vidican Cameras with automatic light compensation circuitry accommodating 5000 to 1 variations in illumination. Capable of at least 500 lines horizontal resolution with a signal-to-noise ratio of at least 40 dB.	$2, 000
2 - Video Switchers: Simple binary switchers allowing switching from camera 1 to camera 2 and back.	$ 600
2 - Pan and Tilt Units with remote controls. Miscellaneous cabling and mounting equipment	$1, 000
Total	$5, 000

c) Video Production Equipment

2 - 1/2 inch Video Tape Recorders compatible with EIAJ Type I standard for Black and White and conforming to the recommended EIAJ standard for color recording. The recorders shall be helical scan type with separate audio and control channels. The recorders will be capable of more than 300 lines horizontal resolution for B & W recording and in excess of 240 lines for color with a signal-to-noise ratio of at least 40 dB. Recorders will provide for assemble and insert editing, dropout compensation, and audio dubbing. Tracking, skew, phase and recording level will be capable of adjustment (Panasonic NV3130, or with acceptance of NTSC color standards and 1-inch format-IVC-800 series).	$ 7, 000 10, 000
2 - Remote Control Zoom Lenses	$ 1, 000
2 - High Resolution Video Cameras with built-in viewfinder, and remote-control of focus, beam, target, pedestal, and gain. Separate mesh vidican capable of 700 lines of horizontal resolution with a signal-to-noise ratio of 40 dB or better.	$ 2, 400
1 - High Resolution Video Camera without viewfinder	$ 600
3 - Tripods w/elevators and dolly's	$ 450
3 - TV Friction Heads	$ 100
3 - 50 ft. Camera Cables	$ 150
1 - Production Control Center incorporating sync generation, audio control, program switching, special effects and dissolve controls, camera controls, and intercom system. The display section of the center would include a minimum of 5 monitors. Provisions would be made for the addition of image enhancement equipment. (Dropout Compensator, Genlock, Image Enhancer, etc.)	$ 4, 000
1 - Portable Lighting System	$ 2, 500
1 - Large Monitor 23" Color	$ 600
Total	$18, 800 - $21, 800

The studio area would be at least 20' x 40' with a minimum ceiling height of 14'. This space could serve as studio for still photography and/or motion picture photography as well as video production if proper attention [illegible] given to the lighting and acoustical treatment of the space.

2. Service Requirements. In the studio area, local control of air conditioning and ventilation and a system with adequate cooling and exchange characteristics will be required. Electrical services for 110 V/15 Amp, and 220 VAC should be provided to power video and subject equipment.

Audio Facility

The production of audio instructional materials to support individualized technical training in the Air Force, and more specifically within the instructional environments described in this report, requires that the audio development facility be designed to support the production of audio tape and audio sound tracks. Audio tapes generated by the facility will be designed to support audio-only instruction, synchronized sound/slide or prenarrated slide sequences and sound filmstrip presentations, and to serve as sources of sound effects and/or background sound for incorporation in motion picture sound tracks. Since motion picture production within the media development facility will emphasize Super 8mm as its distribution medium, the audio facility will also have to support the generation and duplication of magnetic sound tracks.

The compact audio cassette was recommended as the distribution, storage, and playback medium for audio instructional materials. In accordance with those recommendations, the audio facility described in the following pages is tailored to the production of audio materials in two formats: (a) audio cassettes, and (b) magnetic sound tracks.

Staffing

The establishment of the quantitative and qualitative staffing requirements of the audio facility is dependent on the volume of material to be produced by the facility. Specifically, the amount of original audio material (narration, cueing, music, etc.) to be produced will establish the minimum number of personnel required. The amount of duplication and the duplication techniques selected will determine the number of additional personnel required to efficiently staff the facility.

In Table 18, the estimated hours of mediated instruction for each of the baseline courses is shown. For the purpose of sizing the amount of audio material required, the following assumption has been made: Every hour of individualized instruction will be supported by audio material, either as the primary, supplemental or remedial mode of information transmission.

Table 18. Audio Instructional Material Baseline

Inventory Management Course

Total Hours in Course = 240

Hours to be converted to Mediated Instruction	100
Revision Requirement – 10% (estimated)	+ 10
	110
Number of duplicate sets of Instructional Material Required	x 32
Total Number of Audio Instructional Packages	3,520

Precision Measurement Course

Total Hours in Course = 1200

Hours to be converted to Mediated Instruction	120
Revision Requirement – 10% (estimated)	+ 12
	132
Number of duplicate sets of Instructional Material Required	x 24
Total Number of Audio Instructional Packages	3,168

Weapons Mechanic (TAC) Course

Total Hours in Course = 640

Hours to be converted to Mediated Instruction	235 ①
Revision Requirement – 10% (estimated)	+ 24
	259
Number of Duplicate sets of Instructional Material Required	x 32
Total Number of Audio Instructional Packages	8,288

TOTAL:	Hours of Original Material -	501
	No. of Duplicates -	14,976

① includes multiple copies (4) for certain instructional materials required to support team training.

This assumption is amplified in the following manner - every hour of mediated instruction shown in Table 18 will be supported by individualized instructional materials in one of 6 forms; the first five are: (a) still-transparencies (slides or filmstrips), (b) motion pictures, (c) microfiche, (d) video, and (e) text.

The sixth form is audio itself. It should be noted, however, that three of the other media to be used require audio support. Audio information will be required to maximize the effectiveness of any slide, filmstrip, or motion picture presentations used. It is also an integral part of instructional video presentations. Audio, is not required to support the presentation of information via printed texts or microfiche. However, research has shown that audio presentation of materials normally presented in textual form is more effective than text for those with low reading skills (Wepman, 1960; Sticht, 1971). The implication of the research, relating audio presentations and textual information, is that audio instructional materials may be used to supplement even those instructional units which do not require audio as an integral part of the instructional presentation.

Operating on the assumption presented above, it can be seen that the amount of original audio material to be generated is estimated to be approximately 500 hours. This figure, plus or minus ten percent, is felt to encompass the requirements for primary, supplementary and remedial instructional material. This compression of three levels of instruction into the total number of hours to be mediated is felt to be reasonable in that an hour of instruction, supported by a sound-filmstrip, may only require 15 to 20 minutes of audio material. Similar relationships will be found with motion picture presentations.

To support the 500 hours of instruction derived from Table 18 will require a staff of four to six individuals. These individuals will be of three types:

Narrators. Depending on the degree of professionalism required for the audio instructional materials produced by the facility, one or two individuals should be detailed to act as narrators. These need not be full time positions, but in order to facilitate production schedules some control must be possible over the availability of these personnel.

Soundman, Recordist, or Audio Technician. The titles differ, but the function is the same. These individuals are responsible for the technical aspects of preparing any audio instructional materials required, both within this facility and in support of the motion picture and video production facilities. The audio technician's responsibilities will be equally shared between those tasks involved in audio origination - balancing, mixing, recording and quality control - and those tasks involved in preparation of finished audio presentations - editing, dubbing, etc.

The maintenance of recording equipment will also be the audio technician's responsibility. At least two audio technicians will be required to adequately staff this facility.

Duplication Technicians. The master tapes and sound tracks produced by the audio technicians will never leave the audio facility. The output of the audio facility will be judged on the quality of duplicates generated within the facility. The technicians assigned to the preparation of duplicate audio materials will be responsible for the operation of duplication equipment, labeling, packaging and distribution of the audio material produced by the facility.

Audio Materials Preparation

The specific techniques, equipment and processes employed in the preparation of audio materials differ enough with each of the specific applications that they will be treated separately.

1. Audio Tape Preparation. Recording of audio tapes, either to serve as primary sources of instruction or as an integral portion of a combined audio-visual presentation, is a familiar but complex function. It is familiar in that most of us have at one time or another used a tape recorder to produce narrative material. The complexity of the function can only be appreciated in the comparison between the output of a professionally recorded narration and one which is generated on less than quality equipment.

The establishment of a level of acceptable narrative quality (e.g., the professionalism of the recorded voice(s) to be used) is a subjective decision to be made by the Air Force. However, the quantitative characteristics of quality recorded material are known and can be established as operating criteria for audio tape production.

Audio tape production begins with the generation of the narration script. On receipt of a script requiring narration, the responsible audio technician or sound supervisor will meet with the script author and the instructor(s) responsible for the script to determine any special requirements or effects that should be incorporated into the audio presentation. On the basis of this meeting, the narration script will be annotated by the sound supervisor, narrator and the audio technician to establish the cues for the recording session. Any requirement for on-location recording, the collection of background sound, etc., is covered under Magnetic Sound Track Preparation. The remainder of this section refers only to recording studio work.

At this point we will dismiss the narrator's tasks by stating that adequate narration is an art that is mastered through training and practice, but one which is not subject to any discretely identifiable control. The tasks of the audio technician are more visible and are addressable within the boundaries of this report.

The audio technician's equipment can range from a simple monophonic cassette recorder to a fully equipped professional studio. For the development of audio instructional materials, we hypothesize that the level of the facility, equipment quality and operational procedures should approximate that of a professional recording studio. Specific facilities and equipment requirements are covered in succeeding parts of this report. References to facility characteristics and specific equipment capabilities will be expanded in later paragraphs.

Any given audio recording session will require a minimum of two individuals - the narrator and the audio technician. Prior to the start of the session, the responsibilities of the participants can be divided as follows:

Narrator. Review script in detail, check pronunciation of all new terms, establish timing and effect associated with various passages in the script.

Audio Technician. Set up and balance audio gear, ensure proper operation of all gear. With the narrator, establish recording levels, etc.

The major tasks to be accomplished during the recording of narration is the establishment of proper sound balance (particularly if more than one voice is being recorded), and the establishment and maintenance of proper recording volume.

Proper sound balance during recording of speech can be difficult if facilities and equipment are not designed for the task. Achieving a proper reduction of background noise and establishing acceptable levels of reverberation in an existing facility is usually quite difficult unless one is lucky enough to find a room which already has desirable acoustic characteristics. To control these environmental characteristics, it is suggested that a sound booth be installed in the audio facility. Within the booth, the technician would install a condensor microphone with as flat a response curve as possible through the frequency range of speech. The narrator's working distance from the microphone should be between eighteen inches and three feet. Using the narrator as the sound source, the technician should adjust the recording level and/or microphone placement to obtain a crisp natural sound.

The establishment of the proper recording volume can and should be approached both subjectively and objectively. From the objective standpoint, the recording level for narration and announcement recording is between -4 and -8 dB (Nisbett, 1970) for commercial applications, and is recommended as -12 dB by the ANSI standard for audio visual cassette applications (ANSI, 1971). This apparent discrepancy in recording technique is one of the several reasons for the use of more subjective standards in the establishment of a proper recording level. The audio technician will, through experience, have established a feel for what constitutes an acceptable level of loudness. His judgment, however, should be backed by recording some material at a given level and then playing it back through speakers of no better quality than will be used in the instructional environment. Based on this playback, required adjustments would be made to enhance the quality of the recorded passages. Having established the recording level, the audio technician would start the tape and cue the session to begin. During the recording session, the technician's job would be to monitor and control recording level, and to control the switching or fading between microphones and/or other sound sources (music tracks, sound effects, etc.). In the simplest situation, straight narration, it may be possible to use an automatic volume/gain control system, but its utility in situations requiring multiple inputs is limited.

The mixing or adding to the narrative track of background noise, music or special sound effects can be accomplished in two ways by actually doing the mixing while the narrator is recording, or by adding the additional material after the narrator has completed his recording. The first technique is quicker when everything goes well and the number of takes is kept to a minimum. The second technique is safest in that the desired result can be achieved without sacrificing any aspect of quality in the component parts of the recording.

This second approach is recommended for general use in the production of audio material in this facility. The technician would assume responsibility for mixing together required sound effects, music, and/or background noise to enhance the narrator's presentation. This would be done after narration and could be done in three ways. The first technique involves the use of a dual track recorder having both sound-with-sound and sound-on-sound capability. The narration would be recorded on one track. After the narration has been successfully recorded the audio technician has the option of recording his effects directly on the same track as the narration using the sound-on-sound capability of the recorder or the sound effects/background music could be recorded on the second track of the recorder in synchronization with the narration on the first track. The use of the sound-on-sound technique has the advantage of leaving the second track of the master tape free for the addition of control pulses, but is more subject to recording errors with respect to timing and mixing of the narration and the effects. The second technique allows, easier correction of errors, but does require an extra step: duping of the sound-with-sound recording onto a single track prior to the addition of control pulses. The third technique would use three tape recorders: on one recorder would be a blank tape, on the other two would be the narration and a composite tape for the required effects, music, etc. (or separate tapes which would be interchanged as required). A master tape would be created by switching between the two tape recorders while recording on the third. The precision of this approach would be enhanced by feeding the output of the two playback recorders through an audio mixer to the third recorder.

All of these techniques are equally feasible, and the selection of one technique over the other is essentially a preferential one. The latter technique, involving 3 separate recorders, does provide a higher degree of availability by providing redundant hardware components.

2. Magnetic Sound Track Preparation. The preparation of magnetic sound tracks for Super 8mm motion pictures will involve three discrete functions: (a) preparation of voice over narrations and music sequences, (b) on-site recording, and (c) the recording of the sound track on the film itself.

Narration and Other Studio Sound Recording. This type of recording would be accomplished in an identical fashion to that required for audio tape preparation.

On-Site Recording. The recording of audio materials on-site for inclusion in a motion picture can occur in 3 ways: (a) the sound can be synchronized to the film, (b) the sound can be recorded at the same time as the film is being shot, but without any attempt at synchronization, and (c) the sound can be recorded independently of any film work.

Option (a) - Synchronized recording requires the use of special cameras and recording equipment and is only required for those situations where exact synchronization of the dialogue taking place in front of the camera is necessary. Option (a) is not considered to be an essential requirement for successful instructional sound track preparation. However, it will be available with those movies which are originated as video productions and may be used if desired.

Option (b) - So-called "wild-sound" is simply the recording of the background noise and dialogue which is occurring during the filming of a given sequence. No attempt is made to synchronize the filming to the recording and the audio is most often used to create atmosphere for a particular film sequence. Option (b) requires the availability of a portable recorder and quality microphone. Option (b) might be used to create certain effects for instructional motion-picture sound track use.

Option (c) - Is the recording of sound, usually other than dialogue, in locations remote from the studio, usually to serve as sound effects.

3. Sound Track Recording. Actual recording of the sound track on Super 8mm film would be accomplished in the following manner:

1. The work print or the original movie is provided with a magnetic sound stripe and a balancing stripe.

2. The narration, sound effects, and music tracks would be combined onto a single master tape (since synched sound is not being used, there is no requirement to observe cueing discipline).

3. The Super 8mm film with magnetic sound and balancing stripes added is threaded in a properly functioning projector or synchronizer with built-in sound recorder.

4. The film is projected or run through the synchronizer and the tape is cued in at the proper point after a recording level has been established on some blank film or the leader of the recording film.

5. The audio technician would monitor and adjust the sound level throughout the recording process.

Other than the fact that the recording medium is attached to the motion picture film, the process described above is exactly the same as that employed in recording conventional magnetic tape. The significant difference between audio tape recording and magnetic sound track recording lies not in the production of the master but in the generation of duplicate copies.

Copying Audio Materials

The production of duplicate copies of audio materials is a distinct process from the origination of that material, but is just as critical. As in film, there is no evidence that poor duplicates have a negative effect on the instructional value of an audio presentation, but there is evidence that poor quality audio copies can be recognized and labeled as unacceptable or objectionable. This negative effect alone is enough to counter the advantages that may be achieved through the use of individually paced materials.

1. Producing Duplicate Audio Cassettes. The audio master is generated on a reel-to-reel recorder specifically intended for recording purposes. For distribution to students, the material recorded on the master tape needs to be transferred to audio cassettes. The compact cassette offers significant advantages over alternative packaging techniques, particularly with respect to ease of handling and storage density.

In order to produce the volume of duplicate copies required to support the three baseline courses, the audio facility will require a cassette duplicating system. The nature of that system and its employment is dependent on the duplication philosophy adopted by the facility.

There are two alternatives: (a) it can duplicate the required number of copies en masse and distribute the copies to the instructional area, or (b) it can produce one or more "master" cassettes and distribute these to the instructional area for on-demand duplication, using local duplication systems. There are pros and cons to both approaches. Our recommendation is that a centralized duplication facility would service the program, but that one-to-one cassette duplication be available in each instructional facility to permit rapid replacement of damaged lesson segments or to provide take home copy for the students.

The central duplication facility would be an integral part of the audio facility. In order to service the copy requirements of the three baseline courses, the facility would require a cassette duplicating system with four to six copy positions (initially) and a master position for playback of the reel-to-reel master. The exact number of copy stations required will depend on the number of copies to be produced, and the duplicating speed of the copy stations (which, in turn, depends on the selection of the duplicating equipment). Duplicating systems are available in two speeds: 4 to 1 and 8 to 1. At the 8 to 1 duplication ratio a thirty minute tape is copied in 3.7 minutes, while at 4 to 1 the same tape would require 7.5 minutes to duplicate. Thus, a 4 to 1 duplicating system with four copy stations would require 60 minutes of recording time to produce 32 copies, while an 8 to 1 duplicating system would require 30 minutes of recording time to produce an equal number of copies. While 8 to 1 systems cost slightly more than twice that of equivalent 4 to 1 systems, the savings in duplication labor (time spent monitoring the duplication process) would, for the volume and time required in this application, make an 8 to 1 system the best investment. This recommendation rests on the assumptions that the reliability and operational life of the higher speed units are equivalent or superior to that of the lower speed copy units, and that the quality of the copies generated by the higher speed system are uniformly and consistently equivalent to those produced by lower speed copy units. Another factor to be considered is that 8 to 1 units require that the duplicate cassettes be transferred to a separate unit for rewinding while certain 4 to 1 units have built-in automatic rewind systems.

Once the required number of duplicate cassettes have been produced they would be labeled and packaged in accordance with the requirements of the baseline courses.

2. Producing Duplicate Magnetic Sound Tracks. We discussed the technique for generating the sound track for a prototype or master film copy. To generate multiple copies of Super 8mm films with integral magnetic sound tracks requires the selection of one of two processes. One of these is time consuming and the other is expensive. The first of these, which may be adequate if only 1 or 2 copies of each film is required, is to repeat the process for each film copy. The second process

requires that a copy of the film or an equal length of blank, magnetic striped footage be recorded. This length of film would then serve as the master audio track from which successive copies could be made. The transfer of sound from this master sound track to the magnetic stripe on the release prints of a Super 8 presentation would be accomplished using a custom-fabricated "Magnetic Transfer Unit," which is a specially designed tape recorder capable of the synchronized transfer of audio material from an audio master film to multiple copies of a Super 8mm magnetically striped film. Since this device is not yet an off-the-shelf item, the comparative cost of the two approaches cannot be fairly assessed. However, if the number of copies of each individual film exceeds 3 or 4, it would seem worthwhile to investigate the cost effectiveness of procuring a magnetic transfer unit rather than procuring sound track duplication services from outside vendors.

Equipment Requirements

The specific equipment required to support the production of audio instructional materials is listed in Table 19. This equipment complement is seen as adequate to support the development of master audio tapes, master sound track for Super 8mm films, and the duplication of copies of these materials in form of audio cassettes and magnetic sound tracks.

Audio Tape for Integral Tape/Filmstrip Cartridges

The production of audio tape for use in integrated tape/filmstrip cartridges (e.g., Audiscan or Labelle) is similar to that required for the production of all other forms of audio tape, however, duplication and packaging is a more intricate process.

The original or master audio tape for this application is produced in exactly the manner described. After narrative, musical, or sound effects material are recorded, it is a requirement that the master tape be "impulsed," that is, the audio tape must have added to it the pulses or tones which control film progress in the projector. For existing 16mm filmstrip equipment, this impulse coding is critical because every frame must be synchronized to a pulse on the audio tape. Once the impulses have been added to the master tape, it can be duplicated to provide the required number of copies.

Duplication of cartridge tapes is a different and more difficult process than that employed for duplication of cassette tapes. It is possible to record cartridge tapes on conventional reel-to-reel equipment; however, in volume, cartridge tapes are usually recorded on special purpose multi-strand recorders.

Table 19. Audio Equipment Requirements

a) Recording Equipment	Cost
2 - Professional Quality Audio Tape Recorders/ Reproducers (Ampex 500 series, Sony 800 Series, Telex 1000 Series or Equivalent)	$ 2,000
1 - Professional Quality Playback Unit	$ 1,000
1 - Audio Mixer	$ 160
1 - Audio Level Controller	$ 100
1 - Acoustic Correction System	$ 100
1 - Studio Condenser Microphone	$ 200
1 - Cardioid Dynamic Microphone	$ 160
1 - Set of Stereo Headphones W/Monaural Adapter	$ 60
1 - Transcription Turntable W/Arm	$ 300
1 - Portable Tape Recorder W/Microphone & Case (Uher 4000 Series or Equivalent)	$ 500
1 - Degausser	$ 50
1 - Super-8 mm Projector W/Recording Capability	$ 500
b) Duplication Equipment	
1 - Reel-to-Cassette high speed duplicator.	$ 4,000
1 - Cassette to cassette adaptor	$ 1,100
1 - Cassette rewind unit (4 cassettes simultaneously, minimum)	$ 200
1 - Magnetic Transfer Unit	$10,000
Miscellaneous storage, handling and preparation equipment including editors, splicers, etc.	$ 2,000
TOTAL	$22,430

For the production of prototype lots of cartridge tapes the use of two conventional recorders will enable the production of cartridge tapes in a fairly efficient manner, even though cartridge tape is more difficult to handle than conventional tape. The procedure requires that the instructional sequence be repeated several times on a single tape. This tape is then played into the second recorder. The tape on the second recorder is the tape stock which will be used to fill the cartridges. As each repetition of the instructional tape is recorded the copy tape should be cut or marked for later cutting. After cutting, the tape segment is inserted in the cartridge. Volume copying of cartridge tapes is done on duplicators which resemble ordinary tape recorders, but which are capable of accommodating up to 8-parallel tape strands. After recording (usually at 4 to 1 to 8 to 1), the duplicates are wound onto the tape hubs integral to the film cartridges. This is a manual operation which is not subject to simple mechanization. After the cartridge has been loaded with audio tape, the two ends of the tape are spliced together and threaded through the access ports of the tape cartridge. Depending on the sequence in which the tape and film are inserted into the cartridge, the tape section of the cartridge is assembled and the cartridge is either sealed and sent to the instructional department or it is sent to still-transparency facility for film insertion.

Audio Control Signals

Control signals for audio-visual equipment are, at present, pulses of audible or subaudible sound recorded on the audio tape. There are two major approaches and several minor variations to the recording of audio control pulses. The two major approaches are documented in the proposed ANSI standard for audio-visual and educational use of Co-Planar Magnetic Cartridge Type CPII (ANSI, 1971). The first of these techniques uses a 50 Hz superimposed cue tone carried on the same track(s) as the audio. This approach has the advantage of allowing more efficient use of tape, but is handicapped by susceptibility to false triggering by the presence of 50 Hz components in the recorded audio. This use of a superimposed audio control pulse also simplifies tape duplication, but this must be balanced by the restricted number of functions that it is possible to control with pulses in the sub-audible range. Present practice indicates that only two, projector advance and tape stop, are possible with the required degree of reliability.

The second technique uses a separate track for recording control information. Audio information is recorded on one track and control pulses are recorded on a second track. Using this approach with compact cassettes limits the cassette to playback in a single direction, but that is a small price for the greater flexibility of control provided by this approach. The (proposed) ANSI standard identifies four frequencies which are felt to be discriminable when recorded on the same track. Experiments by the authors and other control system manufacturers indicate that there are at least eight separate pulse frequencies which can be compatibly recorded and decoded for control of audio-visual equipment. The only limitation on the number of functions that can be functionally controlled by pulses or tone bursts recorded on a separate track is the discrimination tolerance of the decoding circuitry used. To keep costs within realizable bounds, most manufacturers (and even custom builders) are restricted to tones which are not harmonics of each other. The recommended cue frequencies for separate track systems from the ANSI standard (ANSI, 1971) are 150 Hz, 400 Hz, 1000 Hz and 2300 Hz, all ± 5 percent. The 150 Hz, 1000 Hz and 2300 Hz frequencies have been selected for the control of the audio-visual display system.

1. Recording Audio Control Signals. The procedure for recording audio control signals is an extra step in the preparation of the master tape. A master tape would be prepared in exactly the same fashion. After the master tape has been mixed to include all narration, music and effects, it would be played back while the visuals are being displayed. At each point in the presentation where an image change, program stop, or some other controllable effect is desired, the tape would be impulsed with a proper signal or combination of signals. To accomplish this in an efficient manner pulse generation equipment is required which is designed to output pulses of exactly the right frequency, duration and amplitude. These pulse generation systems should be designed to permit reactive type operation (through the use of easily discriminable pushbuttons, etc.) during complicated, or time constrained pulse sequences. Using the separate track system described above, the control pulses would be input to a separate track. This would require that the tape recorder being used must be capable of recording on one track while playing back the second, e.g. a sound-with-sound recorder.

The recording of audio control signals for filmstrips in the 16mm and Super 8mm formats may require more sophisticated impulsing equipment capable of entering a preset number of pulses while triggering the projection device on a frame-by-frame basis. This capability would be required to impulse motion or animation sequences.

After impulsing, the master tape would be duplicated. However, care must be given to insuring that the duplicator used is capable of transferring the exact track configuration used on the master tape.

Facilities

The space requirements for the audio materials facility would be approximately 500 square feet, preferably in two rooms, one of about 200 square feet and the second of about 300 square feet. The smaller room would be used for recording purposes and would include a sound proof booth for the narrator. The larger space would be used for cassette duplication, packaging, etc. Audio sound track copying equipment (the magnetic transfer unit) would be co-located with the film processing equipment in the motion picture facility.

Services

Normal electrical, ventilation and air conditioning services required for office spaces should be sufficient for this facility. However, electrical services with a higher rating than 15 amps may be required to sustain simultaneous operation of duplication and recording equipment. In addition, special ventilation for the sound proof booth may be required.

REFERENCES

Allen, W. H. Research on new educational media: Summary and problems. Audio-Visual Communications Review, Spring 1959, Vol. 7 (2), 83-96.

Allen, W. H. Media stimulus and types of learning. Audio-Visual Communications Review, January 1967, Vol. 12 (1), 27-31.

Allen, W. H. (Ed.) Readings in educational media theory and research. U.S. Department of Health, Education and Welfare, Office of Education, Bureau of Research, August 1968.

Allen, W. H. Instructional media research: past, present and future. Audio-Visual Communications Review, 1971, Vol. 19 (3), 5-18.

Beranek, L. L. Revised criteria for noise in buildings. Noise Control, January 1957, Vol. 9 (3).

Bitzer, D. L. et al. The PLATO system: Current research and developments. IEEE Transactions on Human Factors in Electronics, June 1967, Vol. HFE-8, No. 2, 64-70.

Bitzer, D. L. et al. A digitally addressable random-access image selector and random-access audio system. CERL Report X-13. Computer-Based Education Research Laboratory, University of Illinois, Urbana, Illinois, August 1970.

Bretz, R. Communications media: Properties and uses. Rand Report RM-6070-NLM/PR, AD696-956. The Rand Corporation, Santa Monica, Calif., September 1969.

Bretz, R. The Selection of Appropriate Communication Media for Instruction: A Guide for Designers of Air Force Technical Training Programs. Rand Report R-601-PR. The Rand Corporation, Santa Monica, Calif., February 1971.

Briggs, L. J. et al. Instructional media: A procedure for the design of multi-media instruction, a critical review of the research, and suggestions for future research. American Institutes for Research, Pittsburgh, PA, Monograph No. 2, 1967.

Briggs, L. J. Handbook of procedures for the design of instruction. American Institute for Research, Pittsburgh, PA, 1970.

Bush, W. J. et al. Same Interactions between individual differences and modes of instructions. AMRL-TR-65-228, AD631-138. Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio, December 1965.

Carpenter, M. G. Maintaining efficient training programs for Air Force technical specialties. Rand Report R-527-DR. The Rand Corporation, Santa Monica, Calif., September 1970.

Cotterman, T. E. *Task classification: An approach to partially ordering information on human learning.* WADC-TR-58-47. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1958.

Dean, C. E. Measurements of the subjective effects of interference in television reception. *Proceedings of the I.R.E.*, January 1960.

Debons, A. Introduction to Display Systems. In H. R. Luxenberg, & R. L. Kuehn (Eds.) *Display systems engineering*, McGraw-Hill, New York, 1968.

Department of Defense. *Human engineering design criteria for military systems, equipment and facilities.* Mil-Std.-1472A, December 1969.

Department of the Air Force. *Instructional system development.* Air Force Manual 50-2, December 1970.

Dreyfuss, H. *The measure of man: Human factors in design.* Whitney Library of Design, New York, 1960.

Eastman Kodak Company. *Photolab design for black and white and color photography.* Kodak Professional Data Book, K13, Rochester, New York, 1968.

Eckstrand, G. A. *Current status of the technology of training.* AMRL-TR-64-86, AD608-216. Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, September 1964.

Educational Facilities Laboratories. *Instructional hardware/a guide to architectural requirements.* Educational Facilities Laboratories, New York, 1970.

Fleishman, E. A. et al. *Development of a taxonomy of human performance: A review of the first years progress.* AFOSR-69-0657. United States Air Force, Office of Scientific Research, Washington, D. C., November 1968.

Folley, J. D. *Development of an improved method of task analysis and beginnings of a theory of training.* NAVTRADEVCEN 1218-1, AD445-869. U.S. Naval Training Devices Center, Orlando, Florida, June 1964.

Fowler, A. D. Observer reaction to video crosstalk. *Journal of the S.M.P.T.E.*, November 1951, Vol. 57.

Frick, F. C. *Educational technology program.* ESD-TR-70-154, AD709-188. Massachusetts Institute of Technology, Lincoln Laboratory, June 1970.

Gagne, R. M. *The conditions of learning.* New York: Holt, Rhinehart and Winston, Inc., 1965.

Goff, J. et al. *Project PIMO final report: Volume II test summary.* AD852-102. Serendipity Associates, Chatsworth, Calif., May 1969.

Grandjean, E. *Fitting the task to the man: An ergonomic approach.* London: Taylor and Francis Ltd., 1969.

Grausnick. R. R. et al. *Microform use in a technical training environment - an experiment.* AFHRL-TR-71-43. U.S. Air Force Human Resources Laboratory, Technical Training Division, Lowry Air Force Base, Colorado, May 1971.

Haggard, D. F. Training Devices. In D. F. Haggard, *An experimental program of instruction on the management of training.* Technical Report 70-9, AD711-948. Human Resources Research Organization, Alexandria, Va., June 1970.

Hoban, C. F., & Van Ormer, E. B. *Instructional Film Research 1918-1950.* Instructional Film Research Program, Pennsylvania State University for U.S. Naval Special Devices Center, Port Washington, NY, Technical Report No. SDC 269-7-19, 1951.

Hovland, C., Lumsdaine, A. A., & Sheffield, F. D. *Experiments in mass communication.* Princeton, NJ: Princeton University Press, 1949.

Kaufman, R. A. The systems approach to programming. In G. D. Ofiesh & W. C. Meirhenry (Eds.), *Trends in programmed instruction.* National Education Association, Washington, D.C., 1964.

Lewis, W. E. et al. *Precision measurement equipment individualized instruction. Phase I: Course analysis and course segment selection.* Interim Technical Report No. 1. McDonnel Douglas Astronautics Company, St. Louis, Mo., September 1971.

Lumsdaine, A. A. Programmed learning and instruction. In E. R. Hilgard (Ed.), *Theories of learning and instruction,* National Society for the Study of Education, Chicago, 1964.

Lumsdaine, A. A. & May, M. A. Mass communications and educational media. In *Annual Review of Psychology*, 1965, Vol. 16.

Meister, D. *Human factors: Theory and practice.* New York: John Wiley and Sons, 1971.

Meister, D. & Sullivan, D. J. *An investigation of the state-of-the-art in instructional technology.* Bunker-Ramo Corporation, Westlake Village, Calif., June 1970.

Miller, E. *Comparison of pictorial techniques for guiding performance during training.* AD730-675. Human Resources Research Organization, Alexandria, VA., June 1971.

Miller, R. B. *Task and part task trainers and training*. AD245-652. American Institute for Research, Pittsburgh, Pa., June 1960.

NAVA. *The audio-visual equipment directory*. The National Audio-Visual Association, Inc., Fairfax, VA., January 1972.

Nisbett, A. *The technique of the sound studio*. New York: Focal Press, Hastings House Publishers, 1970.

Parker, J. F. & Downs, J. E. *Selection of training media*. AD271-483. Psychological Research Associates, Arlington, VA., September 1961.

Parrish, C. R. What media - when? *Air Force Instructors Journal*, Spring 1966, 60-61.

Pieper, W. J. et al. *Automated apprenticeship training (AAT): A systematized audio-visual approach to self-paced job training*. Applied Science Associates, Valencia, Pa., May 1972.

Propst, R. *The office: A facility based on change*. Zeeland, Michigan: Herman Miller, Inc., 1968.

Rhode, W. E. et al. *Analysis and approach to the development of an advanced multi-media instructional system. Volume I and Volume II.* AFHRL-TR-69-30, Volume I and Volume II, AD715-329, AD715-330. Westinghouse Learning Corporation for the Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio, May 1970.

Rome Air Development Center. *A summary of the state-of-the-art in microfilm document storage and retrieval systems.* RADC-TR-67-496, AD820-127. U.S. Air Force, Rome Air Development Center, Griffiss Air Force Base, N.Y., September 1967.

Smith, E. A. *Lenses, films and angles of view*. Technical Training Branch Training Research Division, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, April 1968.

Smith, E. A. *Use of portable video recorders as an instructional system development tool.* AFHRL-TR-71-38, AD737-114. Air Force Human Resources Laboratory, Technical Training Division, Lowry Air Force Base, Colorado, July 1971.

Smith, E. A. & Caudill, P. P. *Selection of rear projection screens for learning carrels.* AFHRL-TR-70-19, AD717-713. Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado, June 1970.

Salomon, G. & Snow, R. E. The specification of film attributes for psychological and educational research purposes. Audio-Visual Communications Review, 1968, Vol. 16, 225-244.

Stitcht, T. G. Learning by listening in relation to aptitude, reading and rate controlled speech: Additional studies. Technical Report 71-5, AD722-480. Human Resources Research Organization, Alexandria, VA., April 1971.

System Development Corporation. ORBIT II System Information. SDC Document SD-3563. System Development Corporation, Santa Monica, Calif., November 1970.

Theile, R. et al. The technical aspects of television program production on film or video tape. Journal of the SMPTE, April 1972, Vol. 81, Number 4.

Tosti, D. G. & Ball, J. R. A behavioral approach to instructional design and media selection. Audio-Visual Communication Review, 1969, Vol. 17, 5-25.

Travers, R. M. W. Man's information system, a primer for media specialists and educational technologists. Scranton, Pa.: Chandler Publishing Company, 1970.

Trow, W. H. & Smith, E. A. An examination of the feasibility of modular design for audio-visual autoinstructional equipment. AMRL-TR-65-79, AD617-608. Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, May 1965.

Trow, W. H. & Smith, E. A. Design considerations influencing the size and cost of optical components in auto-instructional devices. AMRL-TR-65-80, AD617-609. Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, May 1965.

Vlahos, P. Film-based projection systems. In H. R. Luxenberg & R. L. Kuehns (Eds.), Display Systems Engineering. New York: McGraw-Hill, 1968.

Webb, P. Bioastronautics data book. NASA-SP-3006. National Aeronautics and Space Administration, Washington, D.C., 1964.

Wepman, J. M. Auditory discrimination, speech and reading. Elementary School Journal, 1960, 60, 325-333.

Woodson, W. & Conover, D. Human engineering guide for equipment designers. (2nd ed.), Berkeley, Calif.: University of California Press, 1964.

GLOSSARY

Animation Camera. A motion picture camera with special capability for animation work, which usually includes frame and footage counters, the ability to expose a single frame at a time, reverse-filming capability, and parallax-free viewing.

Animation Stand. A specially designed unit for holding and photographing artwork, in which the camera, lighting equipment, registration device, platen, and compound table are an integral part.

Answer Print. The first combined picture and sound print, in release form, offered by the laboratory to the producer for his acceptance. It is usually studied carefully to determine whether changes are required prior to release printing.

Aperture.

1. Lens: The orifice, usually an adjustable iris, which limits the amount of light passing through a lens.
2. Camera: In motion picture cameras, the mask opening that defines the area of each frame exposed.
3. Projector: In motion picture projectors, the mask opening that defines the area of each frame projected.

Audio.

1. The sound portion and/or related equipment of any communication system.
2. Transmission, reception or reproduction of sound.

Blow Up.

1. In transferring an image by means of an optical printer, it is possible to enlarge a properly proportioned fraction of the original image to full frame size in the copy.
2. Optically enlarging one format to another (e.g. 16 to 35mm).

Carrel. A specialized learning area enabling the performances involved in individualized (or small team) self-paced instruction.

Color Correction. Alternation of tonal values of colored objects or images by the use of light filters, either with camera or printer.

Color Temperature. The color quality - expressed in degrees Kelvin (K) of the light source. The higher the color temperature, the bluer the light; the lower the temperature, the redder the light.

Composite Video. A signal consisting of (a) picture signal (including horizontal and vertical components) and (b) synchronizing signal.

Computer Assisted Instruction (CAI). CAI is the use of the computer to control or monitor the learning process of an individual and to modify that process to achieve previously specified goals. The alternatives thru which the computer can act are:

1. Selection of an appropriate media presentation.
2. Control of the rate of presentation.
3. Control of the sequence of elements within a presentation.
4. Concurrent recording of learning behavior.

The important aspect of CAI is the presence of a decision logic for controlling the rate and sequence of presentation based on the student's prior performance.

Computer Managed Instruction (CMI). An automated approach to individualized instruction in which the computer implements the following functions:

1. Diagnostic evaluation and prescription.
2. Schedule development and monitoring.
3. Maintenance of student records.
4. A limited capability for CAI.

In CMI the computer "manages" the progress of a student through a program of instruction, testing at many points, and prescribing progressive or remedial instruction as appropriate.

Cross Talk.

1. Unwanted sound reproduced by an electronic receiver resulting from the inductive effect produced by another transmission channel. Measured as the level at which a tone has been recorded on one channel or track can be heard on the other. It may vary for different frequencies.

Decibel (dB).

1. A measure of the gain or loss of sound energy, intensity or loudness; each decibel gain in sound measurement doubles the intensity of loudness.

2. The decibel is one tenth of a bel. Thus, the decibel is a unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power. Examples of quantities that qualify are power (any form), sound pressure squared, particle velocity squared, sound intensity, sound-energy density, voltage squared. Thus the decibel is a unit of sound-pressure-squared level; it is common practice, however, to shorten this to sound pressure level because ordinarily no ambiguity results from so doing.

Demodulation. The process of removing the video and/or audio signals from their respective carrier waves.

Demodulator. A device which receives tones from the transmission circuit and converts them to electrical pulses or bits which are accepted by the system.

Density.

1. The logarithm of the opacity of developed photographic film. A convenient term used to express the light-stopping characteristic of the film which is often described as "dark" or "light."

2. The quantity of units in a given area; in the case of microform the number of images per unit area.

Distortion.

1. An undesired change in waveform.

2. A flattening of the waveforms in a signal due to excessive amplification.

Dubbing. The addition of sound (either music or dialogue) to a visual presentation via a re-recording process, which prepares a complete sound track (usually magnetic) that can be transferred to and synchronized with the visual presentation.

Dyne. The unit of measurement for force: equal to the force that would give a free mass of one gram an acceleration of one centimeter per second per second.

Editing. The process of assembling, arranging, and trimming the desired scenes and sound tracks to the best advantage for the purpose at hand.

Emulsion Speed. The photosensitivity of an emulsion, usually expressed as an index number based on the film manufacturer's recommendations for the use of the film under typical conditions of exposure and development.

Exposure. The process of subjecting a photographic film to any given intensity of light in such a manner that it will produce a latent image on the emulsion.

Exposure Meter. An optical or photoelectrical device designed to ascertain the amount of light falling on a subject for the purpose of determining the correct exposure of the film.

Feedback. Information as to progress, results, etc., returned to the student.

Field. The portion of the scene in front of the camera represented within the limits of the camera aperture at the focal plane. Area of field thus varies with focal length of lens and camera-to-subject distance.

Film Perforation. Holes punched at regular intervals for the length of film, intended to be engaged by pins, pegs, and sprockets as the film is transported through the camera and projector.

Footage. A length of film (often referred to as a "take"), not necessarily related to a specific number of feet.

Frame. One individual picture, as defined by the limits of the camera aperture, on a piece of photographic film.

Gain. The ratio of on-axis luminance in foot-Lamberts to incident illumination in footcandles. Expressed as:

$$\frac{fL}{fC} = G$$

Genlock. A method/device for controlling the basic frequency of one synchronizing generator so that its synchronizing signals are locked to those of another synchronizing generator.

Graininess. The character of a photographic image when, under normal viewing conditions, it appears to be made up of distinguishable particles, or grains. This is due to the grouping together, or "clumping" of the individual silver grains, which are by themselves far too small to be perceived under normal viewing conditions.

Granularity (see Graininess). Photographically, the term granularity is an objective measurement that correlates with the subjective appearance of graininess. The higher the granularity the more noticeable the grain.

Individualized Instruction. An instructional concept under which a plan of studies is planned and conducted with each student receiving instruction tailored to his learning needs and his characteristics as a learner.

Instructional Medium (PL., Media). The entire system of equipment, processes, people, and materials that are necessary for the presentation of information and direction of learner activity. It often includes the software and hardware; program planning, production, recording and/or transmitting; and program reception. It may also include response methods and/or devices, and feedback to the learner. Instructional media are self-supporting and self-contained means of presentation ---. Their application does not require the presence of an instructor.

Instructional Technology.

1. The application of the products of underlying sciences and disciplines to education and training.

2. A systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and employing a combination of human and non-human resources to bring about more effective instruction.

3. The use of the various theoretical bases for human learning, information transmission, perception, communication, economics and logistics in a combined manner to provide a more logical approach to instruction.

4. The systematic integration of human factors, technological innovations, principles of learning and structure of the subject matter discipline to achieve desired instructional objectives.

Interlace (interlace scanning). A system of scanning in which the electron beam is made to cover the screen in a discontinuous manner. In the most popular system of interlace scanning, 2:1 interlace, the electron beam scans only alternate lines during each trip over the screen. In 2:1 interlace the beam must make two complete trips over the screen to make a complete picture (i.e. frame). Each trip of the beam is called a field.

Kinescope Recording. A film recording made directly from an image on a television tube.

Knowledge. The body of understood information possessed by an individual.

Knowledge of Results (KOR). A form of feedback in which the correctness or incorrectness of his response is returned to the learner.

Linear Programming. A form of instructional programming in which the student's progression is a fixed sequence of incremental steps designed without consideration of variations in individual student performance.

Live Action. Sequences of a film in which live actors or real objects instead of drawings are photographed.

Master. The final negative-reversal positive or intermediate film from which subsequent prints are made.

Medium (PL. Media). (See Instructional Medium)

1. A channel of communication.
2. A substance regarded as the means of transmission of force or effect.

Negative. The term "negative" is used to designate any of the following (in either black and white or color):

1. The raw stock specifically designed for negative images.
2. The negative image.
3. Negative raw stock that has been exposed but has not been processed.
4. Processed film bearing a negative image.

Noise.

1. An erratic, intermittent, or statistically random oscillation. It may be steady, nonsteady or impulsive.
2. Any unwanted signal in a communication or information system.

Oersted. The electromagnetic unit of measurement for magnetic intensity; equal to the intensity of a magnetic field in a vacuum in which a magnetic pole experiences a force of one dyne in the direction of the field.

Original. An initial photographic image, or sound recording - whether photographic, magnetic, or an disk - as opposed to some stage of duplication thereof.

Program (see Programmed Instruction). "An instructional program is a vehicle which generates an essentially reproducible sequence of instructional events and accepts responsibility for efficiently accomplishing a specified change from a given range of initial competences or behavioral tendencies."

(See also Linear Programming and Intrinsic Programming)

Programmed Instruction (PI). A strategy of instruction in which:

1. The process begins with a specific description, in behavioral terms of desired learning outcomes.
2. The program is arranged and sequenced to present a logical sequence of information.
3. The student is required to be an active participant throughout the program.
4. The program provides the student with immediate knowledge of the correctness of his responses.

Programmed Instruction is most often presented for individual, self-paced instruction and is most often associated with presentation via the text medium. However, the defining feature of programmed instruction lies in the process whereby the instruction itself is to be brought about rather than in either the type of programming involved or the method of presentation used.

Projection. The process of presenting a film by optical means and transmitted light for either visual or aural review, or both.

Random Interlace. (TV) In a random interlace system there is no positive control of separation between the lines of the two fields as they are traced across the screen. The odd and even numbered fields are somewhat in relation to each other, but may blend, cross, or impinge upon each other during the tracing of the two fields. Random interlace produces a less stable picture than a 2:1 interlace (see Interlace).

Raster. A predetermined pattern of scanning lines which provides uniform coverage of an area.

Raw Stock. Motion picture film that has not been exposed or processed.

Reduction Printing. The process of producing and recording photographically a smaller image - usually on a smaller film - from a larger image. Film thus made is referred to as a reduction negative or a reduction print, whichever is applicable.

Reinforcement. Any action or event following a response that increases the probability of that response occurring on the next presentation of the same cue/stimulus.

Resolution.

1. The ability of a photographic emulsion to record data, expressed in lines per millimeter. The higher the numerical value, the greater the resolving power of the film.

2. A measure of the amount of detail that can be obtained with an imaging system.

Screen Brightness. The light intensity observed on the screen; this is measured in footlamberts of reflected light for front projection screens, and of the luminous intensity or emitted light in rear screens. Brightness varies as a function of the viewing angle.

Screen Gain. The ratio between observed brightness of a screen at any point (the output from the screen in footlamberts or screen brightness) and the illumination of the screen (by the projector) at that point (input in footcandles). (See Gain)

Signal-to-Noise Ratio. The ratio of the power output of a given signal to the noise power in a given bandwidth.

Simulation.

1. The employment of a representative "model" (physical or logical) of the "real" object under conditions allowing control of the events affecting the "model," so that the response characteristics of the "model" can be clearly identified and the corresponding response characteristics of the "real" object can be estimated.

2. The use of a device or a facility to represent a machine, system or environment and their functions under certain - mostly well specified or controlled conditions.

Simulator (See Simulation). Devices used for simulation.

Simulators have been categorized as "part-task" and "whole-task" simulators. A part-task simulator is defined as a device which represents only specific characteristics or functions of a task, such as radar observation, navigation, or fire control. In contract whole-task simulation has been defined as a deliberate effort to achieve complete representation of equipment characteristics and mission factors. The latter includes the environmental factors which are thought to be important.

Single Concept Films. A short film presentation used to present only one idea, develop it and end.

Sound. Sound is an auditory sensation evoked by the oscillations of pressure, stress, particle displacement, particle velocity in a medium with internal forces.

Sound Effects. Any sound from any source other than the tracks bearing synchronized dialogue, narration, or music, commonly introduced into a master track in the re-recording step, usually with the idea of enhancing illusion of reality in the finished presentation.

Sound Track. The portion of a length of film reserved for the sound record, or any recording so located. Also, any length of film bearing sound only.

Speech Interference Level (SIL). The pressure of an acoustic wave; usually expressed in decibels with reference to the standard of 0.0002 dynes per square centimeter (microbar).

Step Printer. An optical or contact printer in which a motion picture film is printed by stopping each frame in the print aperture.

System.

1. A collection of components, organized to perform a specific function.

2. "A regularly interacting or interdependent group of items forming a unified whole." (Websters 7th)

3. A collection of elements properly arranged, and properly related to each other, so as to serve a particular objective.

Systems Approach (to training). A conceptual framework for planning, orderly consideration of functions and resources including personnel and technical facilities, the kinds and amounts of resources needed, and a phased and ordered sequence of events leading to the accomplishment of specified and operationally defined achievements (see ISD).

Training Aid(s).

1. A device or presentation that is not self contained; a device which does contain narration, commentary, dialogue, captions or any other element in its software required to alow its use in the absence of an instructor.

2. A subset of the inclusive class "media."

Training Devices. The term training devices is used here in a somewhat global sense to include all those physical means appropriate to the presentation of instructional material; as such, it includes:

1. Training Aids

2. Devices for Media Presentation

3. Trainers

4. Simulators

Viewing Angle. The angle described at the center of the screen by the projection axis and the viewers sight line.

Visual.

1. Attained or maintained by sight.

2. Instruction transmitted by means of sight.

Wow.	1. A distortion in reproduced sound consisting of a slow rise and fall of pitch caused by speed variations in the reproducing system. 2. A slow rhythmic variation in pitch due to non-musical causes - described in terms of the percentage variation of speed which occurs in a single cycle of the wow.
Zoom Lens.	A lens whose focal length is variable within specified limits, and is capable of simulating the effect of the camera's movement toward or away from a subject.